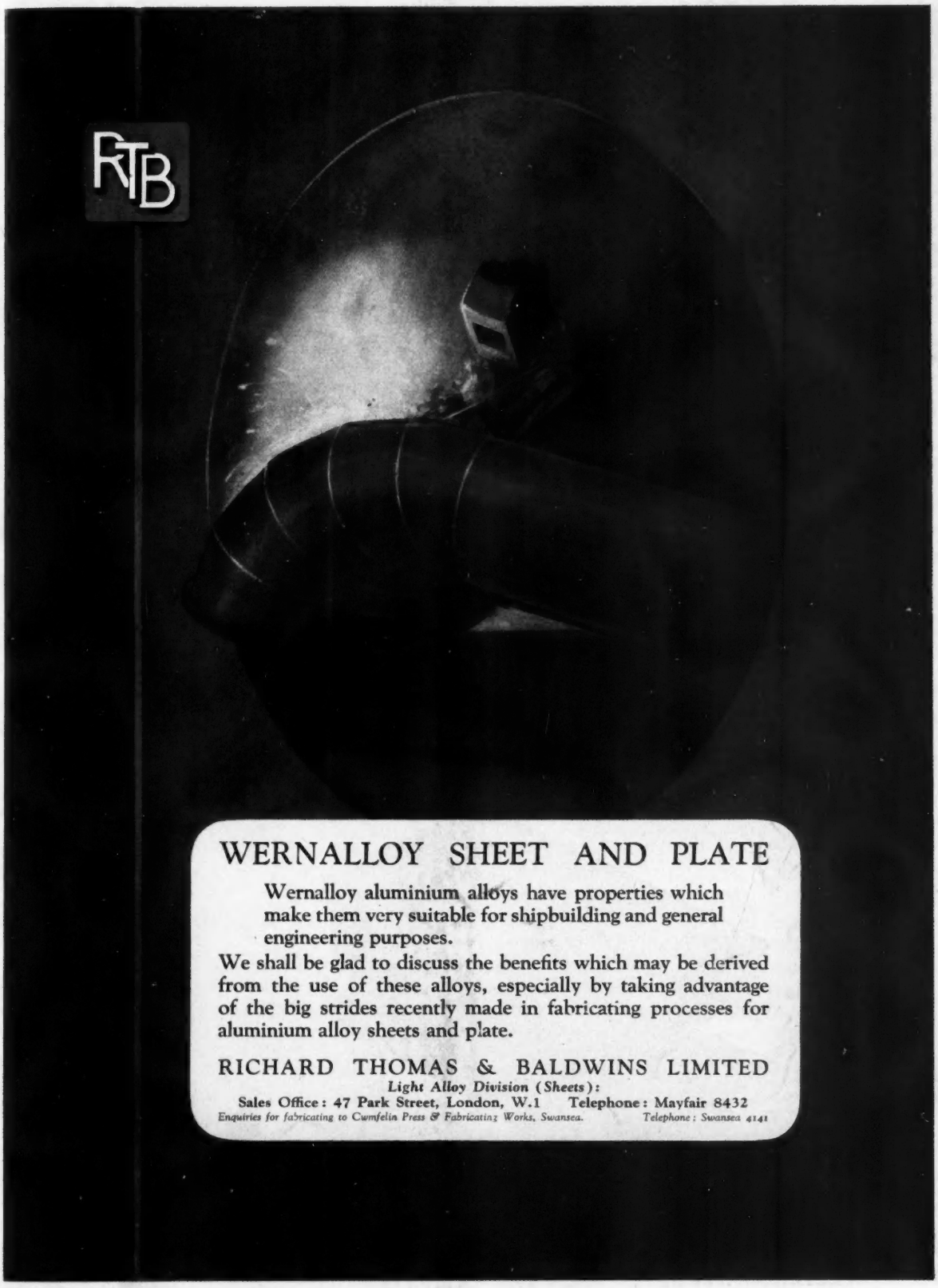
The Engineer

JULY 31, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2. TWO SHILLINGS

UNIVERSITY OF MICHIGAN
AUG 18 1953
ENGINEERING LIBRARY



WERNALLOY SHEET AND PLATE

Wernalloy aluminium alloys have properties which make them very suitable for shipbuilding and general engineering purposes.

We shall be glad to discuss the benefits which may be derived from the use of these alloys, especially by taking advantage of the big strides recently made in fabricating processes for aluminium alloy sheets and plate.

RICHARD THOMAS & BALDWINS LIMITED
Light Alloy Division (Sheets):
Sales Office: 47 Park Street, London, W.1 Telephone: Mayfair 8432
Enquiries for fabricating to Cwmfelin Press & Fabricating Works, Swansea. *Telephone: Swansea 4141*

NEW AND SECONDHAND

PLANT & MACHINERY

FROM THE LARGEST STOCKS IN Gt BRITAIN

SEND US DETAILS OF YOUR REQUIREMENTS

Our Stocks Include :

Machine Tools, Power Presses and Sheet Metal Working Machinery, Hydraulic Plant, Electric Generating Sets, Electric Motors, Switchgear, Transformers, Air Compressors, Boilers, Diesel Engines and other Power Plant, Chemical Plant, Cranes, Locomotives, Plastic Moulding and Rubber Machinery, Pumps, Track and Wagons, Tanks, Steel Sections, Tubes and Fittings, and every kind of Modern Secondhand Works' Equipment.

★ ★ ★

THE 600 GROUP

GEORGE COHEN

SONS AND COMPANY LIMITED

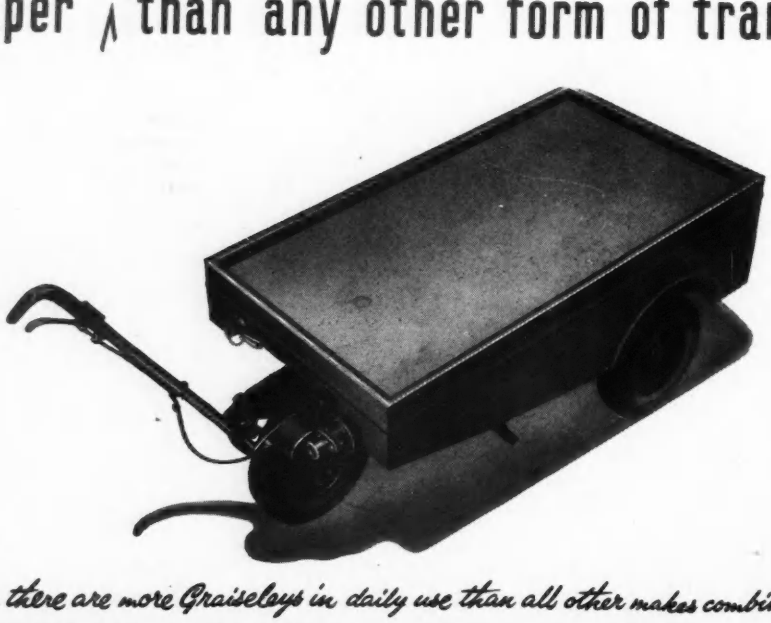
WOOD LANE, LONDON, W.12 'Phone : Shepherds Bush 2070
'Grams: Omniplant, Telex, London

STANNINGLEY, NEAR LEEDS 'Phone : Pudsey 2241
'Grams : Coborn, Leeds

And at KINGSBURY (NEAR TAMWORTH) · MANCHESTER · GLASGOW
MORRISTON, SWANSEA · NEWCASTLE · BELFAST · SHEFFIELD
SOUTHAMPTON · BATH

and often quicker

Cheaper than any other form of transport



You see these Graiseleys everywhere now, carrying loads up to 20 cwt backing into awkward places, taking sharp turns and confined spaces at their stride, doing their ten miles a day for about 3d. The single hand is used for forward and reverse drive, braking and steering, so no skill is necessary. There are no fumes or noise. At night they are simply plugged in and forgotten. The automatic cut-out switches off when the batteries are charged. May we arrange a demonstration for you with your nearest Graiseley service depot.

No wonder there are more Graiseleys in daily use than all other makes combined

DIAMOND MOTORS (WOLVERHAMPTON) LTD.

UPPER VILLIERS STREET, WOLVERHAMPTON

Tel: 22951

THE ENGINEER

JULY 31, 1953

The Royal Aeronautical Society

AT a recent meeting of council of the Royal Aeronautical Society, Sir Sydney Camm, vice-president, was selected president-elect. He will take office as president at the annual general meeting to be held on May 6th next year. Sir Sydney, who is director and chief designer of Hawker Aircraft, Ltd., and chairman of the Technical Board of the Society of British Aircraft Constructors, was created Knight Bachelor last June. Sir Sydney joined Martinsydes, Ltd., in 1914, the founders of this company, Messrs. Martin and Handasyde, being amongst the pioneers of British aviation. He left this company with Mr. Handasyde in 1921, to work on aeroplane design, but in 1923 joined the Hawker Aircraft Company, where he became the chief designer two years later, and director in 1935. He has thus been closely associated with the many famous aircraft which this company has designed and produced. Sir Sydney was made a C.B.E. in 1941 and in 1949 received the British Gold Medal for Aeronautics. He joined the Royal Aeronautical Society as an Associate Fellow in 1918 and became a Fellow in 1932.

"King Edward" Turbines

ON Thursday of this week two of the turbines of the Clyde steamer "King Edward" arrived at the Museum, Kelvingrove, Glasgow, and are to be displayed in a room of the Museum's technological department. The "King Edward" was an epoch-making vessel, being the world's first passenger steamer propelled by steam turbines; it was built in 1901 by William Denny and Brothers, Ltd., and engined by Parsons Marine Steam Turbine Company, Ltd. The principal dimensions of the ship were 250ft by 30ft by 10·6ft, with a gross tonnage of 562 and a draught of 7ft, and propelled by three turbines coupled directly to their respective shafts, of which the centre shaft was fitted with a single propeller of 57in diameter and the wing shafts with tandem propellers of 40in diameter and placed about 9ft apart. The machinery installation consisted of three turbines, of similar construction to those of the "Turbinia," with the high-pressure turbine driving the centre shaft and two low-pressure turbines driving the wing shafts and incorporating the astern turbine in the exhaust casing. On trials the ship attained a speed of 20·5 knots on the Skelmorlie mile, and has continued in service, with boilers and machinery substantially unaltered, for over half a century. In 1951 the ship carried the delegates to the International Conference of Naval Architects and Marine Engineers on a cruise down the Clyde and when she was withdrawn for breaking up there was considerable anxiety that the turbines should be preserved. Through the efforts of the builders of the ship and the makers of the turbines, the Corporation of Glasgow and the Transport Commission, it has been possible to preserve one low-pressure and one high-pressure turbine. They have been overhauled and prepared for display by William Denny and Brothers, Ltd., and placed in a room which, when completed, will be known as the Clyde Room.

Commonwealth Bursaries Scheme

To fill a need with respect to Commonwealth scientific relations the Royal Society and the Nuffield Foundation have jointly decided to initiate a Commonwealth Bursaries scheme, which is being supported by the Nuffield Foundation as a complement to its established programme of Commonwealth Fellowships and other awards. The objective of the scheme is to provide facilities for increasing the efficiency of investigators of proven worth, by enabling them to continue research or follow other forms of study where the physical and personal environment in the Commonwealth are favourable. The main difference from the ordinary Research Fellowship is not only one of duration but of emphasis, since the bursaries aim not so much at solving a particular problem as at improving the powers of the holder to extend the bounds of knowledge. An experimental period of five years is proposed during which time the Nuffield Foundation will provide £5000 a year, which will be devoted to bursaries to United Kingdom scientists wishing to go to overseas parts of the Commonwealth and to scientists of one oversea part of the Commonwealth to go to another. An initial contribution, from the Royal Society, of £2500 will be available for movement in any direction within the Commonwealth, including the United Kingdom. It is hoped that funds may be obtained from other sources to make possible the full development of the scheme, especially by increasing the number of bursaries for scientists of oversea countries of the Commonwealth who desire facilities in the United Kingdom. Each bursary will cover the normal costs for periods of two to twelve months, and the applicant must be sponsored by a recognised research authority and must have prior permission to work in the laboratory or scientific institution chosen. It is expected that Fellows of the Royal Society throughout the Commonwealth will assist in sponsoring and assessing applicants for bursaries, for which it is proposed to consider applications at six-monthly intervals beginning in 1954. On behalf of the sponsors a committee has been set up to administer the scheme, and its membership is Mr. Leslie Farrer-Brown, Sir John Stopford and Professor A. R. Todd, nominated by the Trustees of the Nuffield Foundation; Professor G. R. Cameron, Professor H. S. W. Massey and Sir Eric Rideal, nominated by the Council of the Royal Society, under the chairmanship of Sir Edward Salisbury, C.B.E., and with Dr. D. C. Martin as secretary.

Airline Traffic Statistics for 1952–53

PROVISIONAL figures now published for the financial year ended March, 1953, indicate that the United Kingdom airlines increased the capacity provided on their services to 277 million ton miles, or 12 per cent above the 1951–52 figure. Revenue traffic carried rose by only 10 per cent to 178 million ton miles, as against the 28 per cent recorded in 1951–52. Among factors stated to contribute to this slower rate of growth were the restrictions on services due to the U.S. fuel strike, political disturbances, particularly in the Middle East, the reduced allowance of currency for foreign travel, and unfavourable economic conditions affecting freight traffic. Although adversely affected by some of these factors, passenger traffic was stimulated by the introduction of tourist fares on the North Atlantic in May, 1952, and the numbers of passengers carried on all services increased to more than 1,750,000, 23 per cent above the figure for the previous year. Mail ton miles increased by 4 per cent while freight ton miles fell by 2 per cent compared with 1951–52. The British Overseas Airways Corporation provided 203 million capacity ton miles, an increase of 9 per cent, and its total traffic rose by 7 per cent. The Corporation carried nearly 275,000 passengers. The total traffic on British European Airways' services increased by 18 per cent to almost 43,000,000 ton miles. Capacity provided increased by slightly more than this, and the overall load factor fell from 65 per cent in 1951–52 to 63 per cent. B.E.A. carried nearly 1,500,000 passengers. Domestic services showed a striking improvement over 1951–52, with an increase of 33 per cent in passenger miles flown. While there is evidence that the reduced currency allowance for foreign travel contributed to the heavier traffic on internal services during the summer, very substantial increases resulted from cheap winter fares on some domestic trunk routes. Capacity provided on services operated by independent companies increased by 51 per cent over 1951–52 and total traffic increased by 71 per cent. Passenger traffic showed the greater increase, passenger miles flown being 28,000,000 compared with 12,000,000 last year. The overall load factor improved to 66 per cent compared with 58 per cent in 1951–52.

Chemical Research in 1952

THE annual report of the Chemical Research Laboratory was issued last week by the Department of Scientific and Industrial Research. It is recorded in the report that two new buildings for radio-chemical and micro-biological research were completed during 1952, with which it will be able to tackle new work not previously possible. From work carried out by the Corrosion Group, it has been disclosed that a suspension of sulphur in distilled water rapidly corrodes mild steel. The effect of a 20 per cent solution was greater than that of 3 per cent hydrochloric acid. The discovery has been applied in developing a method of etching mild steel which has advantages over the use of acids. Corrosion of buried pipes continued to be one of the most important problems that the group deals with. Two clay soils were examined in which the expected attack on buried iron had not taken place. In the first, sulphate reducing bacteria were absent owing to a toxin produced by a species of fungus. In the second and more spectacular example, it was found that tannin in the soil had almost completely prevented the corrosion of iron articles more than 2000 years old. It is noted in the report that the Radiochemical Group has succeeded in developing an ion exchange process for the recovery of gold and other metals from cyanide solutions used in the extraction of gold ores. Another notable advance by the group was the separation and determination of niobium and tantalum by chromatography. The method is being used by other laboratories. Radioactive tracer techniques have been used in the study of the mechanism of corrosion inhibitors, in chromatographic separators and in evaluation of the naphthalene content of coal tar. Work by the Inorganic Group on the production of phosphate fertilisers has continued, most attention being given to processes which do not need sulphuric acid. The production of dicalcium phosphate from nitric acid attack on phosphate rock was investigated. The use of this compound as a fertiliser overcomes the caking problems which arise during storage of fertilisers containing calcium nitrate. Another advantage is that during manufacture nitric acid is regenerated for further attack on the rock. The group is also working on the possibilities of making phosphoric acid and phosphate fertilisers from a Uganda apatite. From other items recorded in the report it is noted that research on the micro-biological production of sulphur and sulphide was intensified and work is now directed to finding suitable quantities of a cheap fermentable material as a carbon source. The report is published by Her Majesty's Stationery Office, price 4s. 6d.

Paint Coating Thickness Meters

By R. QUARENDON, Ph.D., B.Sc., D.I.C., A.R.C.S.

No. I

Various commercial and other meters which during recent years have been made available for the measurement of the thickness of paint coatings are described. The various meters described include those for the measurement of coatings on magnetic and non-magnetic bases, and on conducting and non-conducting bases. One or two meters have been designed for wet films. The instruments described are of British or American manufacture. The design, method of use and limitations of the meters are described, with some remarks on methods of calibration and accuracy.

INSTRUMENT designers have given much of their time in recent years to serving the paint coating application industry. Paint users can now call upon an increasing variety of instruments to assist them in their work, and can operate on a more rational and economical basis than was previously possible.

Prominent among instruments which are becoming increasingly available is the paint coating thickness meter. In the past, the lack of convenient means of measuring coating thickness has been a considerable handicap, for example, in the study of finishes in the aircraft industry. This handicap has now to a large extent been removed.

An accurate knowledge of coating thickness is desirable for several reasons. It helps to improve quality and to cut down costs by giving better control of the finishing process. Under- or over-application of the paint may retard the proper development of important physical properties on which the quality of the finished work depends, such as adhesion, elasticity and durability.

Guessing at the thickness of a coating can often lead to disappointment and unnecessary expense. Full protection against corrosion over the whole surface of a job may demand a minimum local thickness of 5 mils—a result which thickness measurements have shown cannot be guaranteed with some kinds of finish by the standard three-coat schedule. One can therefore understand why so much effort has been devoted to the evolution of new types of gauge and to the improvement of old ones.

Many of the commercial thickness gauges now available have rather specialised uses. The all-purpose gauge suitable for all problems is perhaps an unattainable ideal. Accuracy must often be sacrificed to speed, and a limited range of thickness measurement is sometimes the price to be paid for high sensitivity or the ability to deal with moving material.

Ten or fifteen years ago the coating industry relied largely upon two or three well-known thickness meters, including the General Electric Company's "Enamel Thickness Gage" and the "Brenner Magne-Gage." These instruments found, and still find, wide acceptance in their special fields. Their usefulness was, however, restricted to non-magnetic coatings on magnetic bases; now a much larger variety of meters adapted for diverse conditions and circumstances are available to the paint technician, who has a much wider choice for the attack upon different problems in the industry.

Although new physical techniques or new materials have made it possible to devise new meters, most of the gauges introduced during recent years do not involve the use of radically new physical principles. Improvements in design have permitted the extension of older techniques to new fields of usefulness, or have increased the reliability or convenience of existing meters. Possibly the only rather new technique is the use of radiation from radio-active isotopes, yet this approach cannot be regarded as quite new, since radium and X-rays have been applied to similar ends for many years.

Although many methods have been applied to the measurement of the thickness of materials in the form of homogeneous sheet or film, such methods are not all suitable for use with coatings of various kinds applied to base materials. The accurate measurement of the thickness of an applied coating is a more difficult problem. Apart from the need to find a convenient physical property to distinguish the film from the base material, it is usually also necessary to consider the relative thicknesses of the coating and the base. As the coating is often only a small fraction of the total thickness, it is not always easy to secure the desired sensitivity.

Common Characteristics

Most thickness meters have properties in common which are necessary for accurate and reliable results. These properties are basic to good instrumentation and are not peculiar to those meters under review. Two very important matters are the provision of means for adjustment of the zero and also of the sensitivity.

Adjustment of the zero is necessary in various circumstances. As the ability to discriminate between the coating and the base material is essential for the operation of the meter, a change in the property of the base can alter the zero reading of some kinds of meter, as can changes in conditions such as the operation of the auxiliary electrical circuit and others not directly related to coating thickness. The zero adjustment is usually done by placing the measuring head in contact with a sheet of material similar to the base material and turning the control knob until the indicator points to the zero of the meter. It is usually necessary to use a piece of base metal of the same size and shape as the test piece.

The need for sensitivity adjustment usually arises from a different cause, being dependent on the properties of the coating rather than that of the base metal. If this were not provided, the use of some kinds of meter would be restricted to the particular material for which the meter had been calibrated. Changes in the working conditions involved in the design of the meter may also alter the sensitivity. Adjustment of the sensitivity means obtaining at least one "fix" on the scale in addition to the zero, to correspond with a known thickness of the coating to be measured, or periodical checks against a standard reference test piece.

Method of Obtaining Sensitivity

A coating thickness meter is a relatively refined instrument, especially when it is required to measure a thickness of a mil or two. Small disturbances of the conditions, as, for example, instability of the electrical circuit, can therefore have an important effect on the accuracy of the measurement. It is largely in this respect that improvements in performance have been made in recent years.

One important principle which is incorporated in some electrical instruments is the use of a bridge circuit, in which the physical property being measured is balanced against the same property in a reference coil. This is the well-known null method of measurement widely used where small electrical currents or voltages are available for measurement. Fluctuations in external conditions, such as the applied voltage or frequency, are thus cancelled, and only the out-of-balance effect produced by the presence of the paint coating registers on the meter. For the same reason some designers of thickness meters have found it necessary to modify the design of their instruments and to include a device, such as a baretter, for the stabilisation of the voltage fed to the instrument from the mains.

Most makers of coating thickness meters stipulate limitations of size and shape if the performance of the meter is to conform with the accuracy claimed for it. These limitations are not usually very serious but may mean that good results cannot be obtained with very small test pieces. The limiting dimensions recommended by the makers are stated in the article.

The condition of the surface of the base material can have an important effect on the accuracy of the measurements made with some kinds of meter. With those meters which utilise the difference in the magnetic properties of the coating and the base, quite a small degree of roughness of the base can interfere with the operation of the meter, by introducing an air gap between the measuring head and the base metal. For this reason the setting of the zero should be done on a smooth surface; if the available material is rough, it must be polished, either by buffing or by the use of polishing papers. Roughness of the coating can also cause inaccuracy for a similar reason, but a given degree of roughness here seems to have a smaller effect than in the base metal.

Where the instrument does not contain any provision for zero adjustment a correction may sometimes be made to the original instrument calibration to allow for a change in the condition of the base material. The magnitude of this correction is determined by observing the meter reading with the measuring head in contact with the polished surface of a sample of the base metal in question; the difference between this reading and the zero on the scale is the correction required. It is here assumed that there is a linear relation between the thickness and the property being measured and that the correction therefore applies uniformly to all parts of the scale.

Primary Methods

The advent of modern coating thickness meters has brought a great gain in speed and convenience. Before such meters became generally available, it was necessary to rely on laborious methods of measurement, sometimes involving the removal of the paint from the base material. Destructive methods of this kind are not now generally necessary, although until fairly recently, for some purposes, there was no practicable alternatives for repetition work.

Most industrial thickness meters for routine use in the field are secondary meters. That is to say, they utilise some property related to the thickness, and do not measure thickness directly. Hence it becomes necessary

to calibrate them by the use of measurements obtained by some more fundamental primary method. For this purpose stripping of the paint film from the surface, combined with weighing, is often used. For some purposes test pieces of standard thickness may be obtained, such as Johannson gauge blocks, by which the calibration of the instrument may periodically be checked.

Alternatively, a spherometer or micrometer may be employed.

Classification of Meters

The thickness meters described in this article will be classified under the following heads. They represent some thirty different meters available in this country and Europe.

(1) Meters for films on magnetic bases, usually iron and steel. This class of instrument may be sub-divided into two smaller classes, one in which the effect of the film in modifying the magnetic flux is translated into some other property such as the current in the test coil, and another where the property utilised is the attraction of the base metal for a magnet. The former class may be regarded as coming under the heading of reluctometers.

(2) Films on electrically-conducting bases, not necessarily iron or steel. Here the film functions as a dielectric in modifying the electrical properties of the base metal.

(3) Capacitance meters, in which the presence of the film alters the electrical capacitance of the film-base combination.

(4) Penetrometers. In this type of meter the depth of penetration of a needle or some sharp object through the film is measured.

(5) Radiation Gauges. In these instruments, the effect on which the measurement depends is the reduction of the intensity of radiation, obtained either from a radioactive source or in the form of X-rays.

Coatings on Magnetic Bases

This heading covers by far the largest class of currently available coating thickness meters. It includes some of the earliest and best-known gauges, and represents one of the first successful attempts to produce a commercial instrument for this purpose.

It is easy to understand why so much attention has been given to the development of this class of meter ; it is capable of a high degree of accuracy, because of the relative ease with which it is possible to distinguish between a non-magnetic coating and a magnetic base : it lends itself to the use of sensitive and convenient electric methods of measurement, and there is also the important practical fact that, apart from wood, iron and steel are by far the most important constructional materials requiring protection by a paint film. Its use is not confined to the testing of paint films, but extends to the accurate high-speed routine testing of machine parts.

Although nearly all meters for use with magnetic bases operate on the principle that the presence of the non-magnetic coating reduces the intensity of the magnetic flux in the measuring head, a wide variety of methods are used to detect the change and to translate it into any easily measurable property. The most sensitive meters of this type employ electrical measuring instruments ; they involve some degree of additional complication and expense, however, and where it is desired to have a meter of rather simpler designs it is possible to use more direct methods at the expense of somewhat reduced accuracy.

Meters designed for use with coatings on magnetic bases may be subdivided into several broad general classes, each of which includes instruments differing in particular features introduced to secure particular advantages. They may, for example, differ in the nature of the electrical circuit employed, or in the method of detection of the point of balance if a null method is used, and so on. Some of these differences may be introduced for convenience, others to give the desired sensitivity, and for other reasons, but all such instruments depend basically on the effect of the paint film in modifying the strength of the magnetic flux. Although they may, therefore, in a sense be regarded as reluctometers, it is more convenient to restrict this term to instruments where the change of flux directly affects the meter of the instrument instead of indirectly via the medium of some subsidiary circuit.

Gauges in which the change of reluctance is measured in an indirect manner, by its effect on some electrical property of the detector or probe coil, are more conveniently classified under other headings; these classes include impedance meters, transformer circuit instruments, and inductance meters. There are also magnetic attraction gauges, in which the property measured is the magnetic force between the coated base and magnet of suitable design. Such an instrument can be made very simple, and this class includes some of the best-known coating thickness meters. Either a permanent magnet or a solenoid may be used for attraction gauges.

Examples of these various gauges are the enamel thickness gauge made by the General Electric Company, U.S.A., the layer thickness gauge made here by the General Electric Company, Ltd., and the Taylor-Hobson thickness gauge. The inductance meter can be adapted to the measurement of films on non-magnetic bases, as in the Gordon Richmond gauge and the American Instrument Company's " Filmeter," by suitable modification of the technique. These gauges are described below.

Most of the electrical thickness gauges employ alternating current taken from the mains supply, instead of direct current, partly because this form of electrical energy is an excellent method of discriminating between the magnetic or electrical property of the base and the film, and partly because it is necessary for translation of the change of magnetic flux into electrical current or potential or property alternatively being measured. It has the obvious advantage that it avoids the use of a rectifier for conversion of the alternating to direct current.

Magnetic attraction gauges designed to use an a.c. solenoid, however, have one drawback compared with a d.c. instrument ; a very noticeable " chatter " occurs at the instant of breakaway, when the measuring head is being detached from the surface at the instant of taking the meter. This chattering tends to cause some unsteadiness in the meter reading.

With tacky films, care must be taken to see that the apparent magnetic attraction is not due to the sticking of the film to the magnet. This source of error is most serious with very thin films.

Generally speaking, the thickness of the base metal on which the coating is applied is far from critical. It may be as little as 10 mils thick without causing any serious error, unless it is a metal with a low permeability such as high-carbon steel ; in this event, the thickness of the base metal should usually be not less than about 50 mils.

It is now proposed to describe representative meters from each of the above class of instrument, all of which are in commercial production.

One of the earliest and most widely used gauges is the enamel thickness gauge made by the General Electric Company of America, introduced some fifteen years ago to supersede the needle micrometer once made by this company. The change of magnetic flux produced by the coating is measured in an indirect manner by its effect on the impedance of the coil in the measuring head.

The measuring head (Fig. 1) consists of a coil fitted at one end with parallel large disc-shape pole pieces. When in use, these pole pieces rest with their edges on the coating whose thickness is being measured. When the coil of the measuring head is energised by alternating current, the pole pieces become magnetised, and the flux passes between them through the iron or steel base below the coating. The presence of the non-magnetic coating changes the flux ; the thicker the coating, the weaker the flux and the smaller the impedance of the coil.

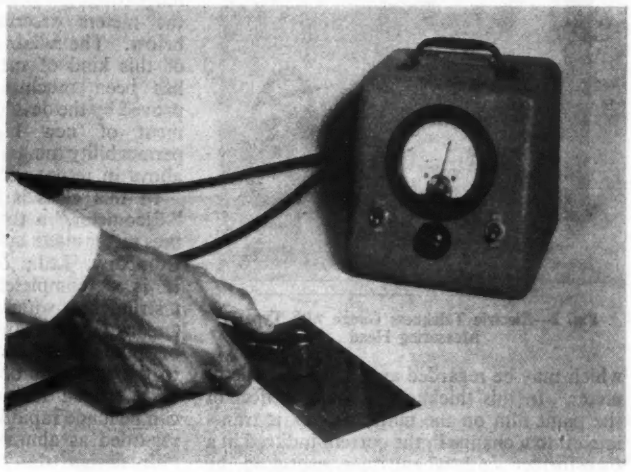


Fig. 1—Enamel Thickness Gauge

For good sensitivity the coil in the measuring head is arranged in opposition to a similar coil housed in a separate unit containing the electrical gear and the meter proper, and connected via a length of cable to the measuring head. To make a measurement of coating thickness the two coils are brought to a condition of balance when energised from the a.c. mains supply, so that the needle of the meter points to zero. The head is then placed lightly in contact with the coating, when the out-of-balance current causes a deflection of the needle on the meter scale.

The gauge is designed to cover a total thickness range from 0·5 to 100 mils in six steps. It is usually calibrated by the use of " Cellophane " or similar films. For good results it is necessary to be sure that there is no gap between the coating and the measuring head, as this would be measured as if it were a coating of equivalent thickness. The gauge cannot be used for coatings on aluminium, copper or magnesium.

The thickness gauge made by Taylor, Taylor and Hobson, Ltd., of Leicester, is somewhat similar to that just described,

inasmuch as the change of magnetic flux caused by the paint film produces a change in current in the coil of the measuring head (shown in Fig. 2). The circuit used to translate the current deviation into meter reading is, however, not the same. In the Taylor-Hobson gauge this deviation is detected by the unbalance of a Wheatstone's bridge, in which the coil of the measuring head and a reference coil are incorporated. In the " zero " position the currents in the two coils are in balance when the meter is energised ; when the paint coating is interposed an out-of-balance potential develops across the bridge and is indicated on a millivoltmeter whose scale is calibrated in mils of thickness.

In this country the General Electric Company, Ltd., makes a layer thickness meter,

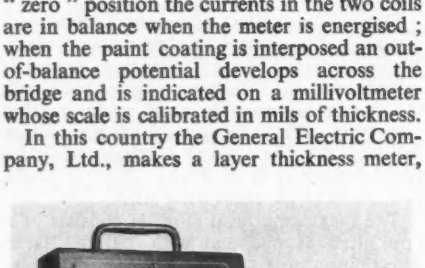


Fig. 2—Electric Thickness Gauge with Type B Measuring Head

which may be regarded as a form of reluctometer. In this thickness gauge the effect of the paint film on the magnetic flux is translated into a change in the current induced in a transformer coil when it is energised by alternating current.

The measuring head of this gauge has three prods, one of which is the primary winding of the transformer and the other two are the ends of the secondary winding of the transformer. When a current is passed through the primary winding a current is also induced in the secondary winding ; the magnitude of this current depends on the intensity of the magnetic flux in the core of the coil. Since the presence of the paint film between the iron or steel base and the coils is equivalent to an air gap, it reduces the magnetic flux and therefore the voltage induced in the secondary winding. This induced voltage is used as a measure of the film thickness ; the smaller the magnetic flux the smaller the voltage and *vice versa*.

Coatings up to 30 mils in thickness may be measured by the use of this G.E.C. instrument meter with an accuracy claimed to be plus or minus 10 per cent. For the best results the size of the test article must be at least 4cm square and 0·75mm thick, and the distance between the measuring head and the edge of the article should not exceed 1cm. Inaccuracies may be caused by the presence of dust on the base metal when setting the zero of the instrument, and by a difference in the sizes of the coated and uncoated articles, unless they are both very much larger than the measuring head.

Coatings on bases made of stainless steel or some grades of high-carbon cast steel are not suited to this method of measurement because of the low magnetic permeability of these materials.

A similar instrument is made by Marconi Instruments, Ltd., of St. Albans. The presence of the paint film produces an unbalance between the two opposed primary coils of a transformer housed in the measuring head ; the resulting current induced in the secondary circuit is used as a measure of the thickness of the paint film. The meter is designed for the measurement of thicknesses from nil to 10 mils. The instrument is illustrated in Fig. 3.

The above-mentioned thickness meters have the disadvantage that they need an external source of energy for their operation, are not very easily portable and require periodical checking of the electrical circuit. For many purposes a more mobile type of meter finds a great demand. This can be achieved by using a permanent magnet in place of the electromagnet, as is done in the meters described below. The reliability of this kind of meter has been much improved by the development of new high-permeability magnetic alloys in recent years.

In this class is the " Elcometer," a thickness meter made by East Lancashire Chemical Company, Ltd., of Fairfield, Manchester. It is a completely self-contained pocket instrument, which is small and light and capable of an accuracy to within plus or minus 5 per cent or 0·01 mil, according to the thickness of the coating. By the use of a special locking device, measurements can be made rapidly in what would usually be regarded as almost inaccessible positions.

In design, the " Elcometer" consists of a " U "-shaped permanent magnet, the poles of which terminate in hard chromium-plated contact spheres, which act as the test prongs of the meter. When these prongs are brought within range of the painted iron or steel base, the magnetic flux in the circuit produces a deflection of a pivoted magnet needle placed within the " U " at the other end of the magnet. A helical spring attached to the pivot is used to damp the vibration and prevent uncontrolled swinging of the magnet.

As in other kinds of reluctometer, the flux diminishes as the thickness of the paint film increases and the deflection of the pointer attached to the pivoted magnet is therefore also reduced. The end of the pointer moves over the scale of the meter, which may be calibrated for the desired thickness range, up to a maximum of about 80 mils.

Fig. 3—Thickness Meter in Use

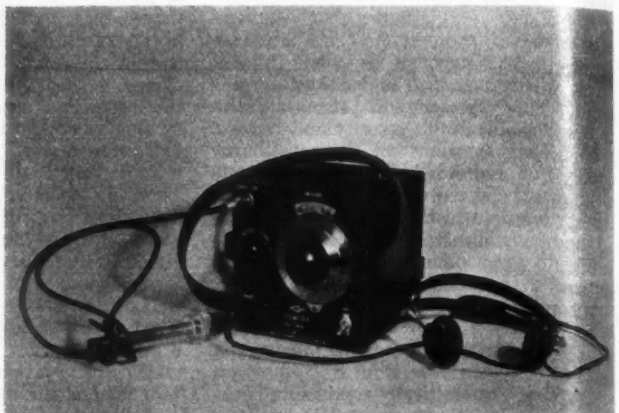


Fig. 4—" Filmeter "

Point measurements may be made with this type of meter on large or small sheets, and it may be used on curved or flat surfaces, provided that the radius of curvature is not less than $\frac{1}{8}$in, or 1in for convex and concave surfaces, respectively.

The General Electric Company, Ltd., has recently introduced a meter of the same kind, which it calls the miniature layer thickness meter, as a companion to its electrically-operated meter. This meter has one test probe at the end of the magnet instead of the two probes in the " Elcometer." After zero adjustment the meter is placed with the probe in contact with the paint film and the thickness is read on the scale. Films on sheet iron down to a thickness of 0·01in and 2in square, and strip material down to $\frac{1}{32}$in thick and $\frac{1}{4}$in wide and 10in long may be measured. The minimum convex and concave radii for reliable results are $\frac{3}{4}$in and 3in, respectively. The net weight of the instrument is only 6 oz., and it is available for three scale ranges, from nil thickness to 5, 10 and 30 mils.

Inductance Meters

The design of most gauges intended for use with coatings on magnetic bases precludes their use with non-magnetic metal bases. However, some modification in the design of the inductive type of meter enables this restriction to be removed, as has been done in certain gauges of recent design. One of these is the meter developed by Charles C. Gordon and Joseph C. Richmond at the National Bureau of Standards, Washington, in a project sponsored by the National Advisory Committee for Aeronautics, with particular reference to non-magnetic high temperature alloys ; another is a commercial meter developed by Dr. J. E. Dinger of the Naval Research Laboratory at Washington and now manufactured by the American Instrument Company and known as the N.R.L. " Filmeter " (Fig. 4).

With gauges designed for use on magnetic bases, the permeability is so great

that the necessary sensitivity is fairly easily attained at ordinary mains frequencies; with non-magnetic materials, however, it is necessary to energise the coil at a much higher frequency. This is done by means of a high-frequency oscillator in a bridge circuit, with the test coil of the probe head in one arm and a reference coil in the other. The Gordon and Richmond gauge uses an oscillation frequency of 500 kc/s.

The probe coils of these two gauges are arranged to function as transformers, but instead of having a soft iron core, they use the metallic base below the coating as the transformer secondary, coupled with the probe coil as primary. Whereas in the N.R.L. "Filmeter" the bridge is brought to balance by a variable capacitor having a dial calibrated in terms of coating thickness, the Gordon and Richmond gauge employs a sensitive galvanometer for the indication of the bridge balance and coating thickness.

The Gordon and Richmond gauge employs an electric oscillatory circuit which, with the reference coil, is housed in a cabinet connected to the measuring head via a shielded cable. The arrangement of the N.R.L. "Filmeter" is somewhat similar, but uses a rather unusual method of detecting the point of balance of the test and reference circuits. In the latter instrument the point of balance is found by audible means, by listening for "beats" in a pair of headphones; for this reason it is described as a "beat frequency oscillator."

In use, the box containing the "works" of the N.R.L. "Filmeter" is slung round the neck, leaving one hand free to turn the calibrated dial and the other to manipulate the test-head. The zero of the instrument is first set by placing the head in contact with the unpainted base material and turning the dial until the absence of beats indicates that the currents are in balance.

To make a measurement, the procedure is then repeated with the head in contact with the surface of the paint film and the thickness is read from a calibration curve prepared from measurements made on films of known thickness. The instrument is readily portable and is suitable for use in the field. According to the makers, readings may be taken in 30 seconds. The radius of curvature of the test specimen must not be less than 6in, while for accurate results with the N.R.L. "Filmeter" the alloy, temper and smoothness of the metal on which the zero is adjusted must be the same as that underlying the film whose thickness is being measured.

The N.R.L. "Filmeter" is intended for relatively thin coatings, those ranging from nil to 5 mils; on the other hand, the Gordon and Richmond gauge can be used with coatings up to 90 mils. The accuracy claimed for the former gauge is 3 per cent of full scale range for 1–5 mils, and 5 per cent for 0–1 mil; for the latter gauge it is about 1 per cent for all thicknesses.

The principle of another meter made by Nash and Thompson, Ltd., of Tolworth, Surrey, is similar to that of the American Instrument Company's NRL "Filmeter," but it has a "magic eye" for giving visual indication of the position of balance of the calibrated dial, instead of earphones for audible indication by absence of beats.

(To be continued)

PRESTWICK AIRPORT.—The Minister of Civil Aviation has announced that the construction of a new subsidiary runway at Prestwick will be started next year. This runway, together with a new control tower, should be completed in 1956, and Prestwick will then be suitable for all existing types of civil aircraft in all wind conditions.

Forms of Sections for Struts

By. C. G. WATSON

This article amounts to an attempt to evolve the most efficient form of section for use as a strut, consistent with its practical usefulness in the construction of transmission line towers and similar structures.

THE material considered in this article is the aluminium alloy Noral 51ST. The effect of torsion has not been taken into account in the numerical results given herein because the difficulties of calculation have been found insuperable. Simply, the sections have been drawn and the moments of inertia and other properties determined, partly graphically and partly, using text-book formulæ, by calculation. In addition, however, a method of evaluation is used which may be as useful a guide as mathematics. At first sight it may seem that the procedure adopted is unlikely to give results of practical value. Reflection, however, indicates that, provided the length of outstanding leg be within the limit set by the material and provided that the slenderness ratio be high, say, not less than 60, the results as calculated, would approximate to fact and, as that ratio is the economic low limit of slenderness, would have practical value to the extent, at least, of determining what sections should be tested experimentally.

General Considerations

Unit of Length.—Unless otherwise stated, the unit of length used herein is the thickness of the flange in each case, which in every case here examined is also the least thickness of the section.

Limits to Design.—Method of manufacture and field conditions impose limits on the use of a section of any particular form. The extrusion process, here taken as the method of manufacture, although some of the sections could be rolled, sets a limit to the relation between maximum overall dimension and minimum thickness of section, and

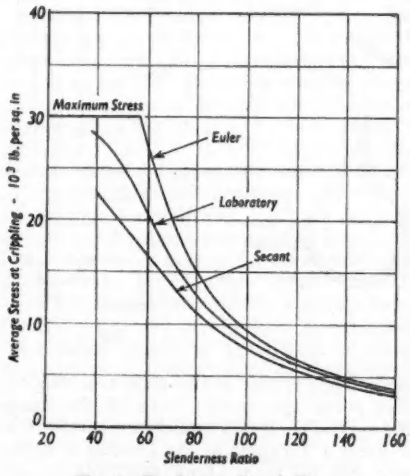


Fig. 1—Slenderness Stress Chart

on the maximum size of an extrusion. Here the maximum ratio of overall width to minimum thickness is taken as 35, and the maximum size is that which will just go into a 12in diameter circle.

Important field limits are minimum thickness of section and minimum diameter of bolt. They vary with person, place and purpose. For the present, to cover all the variations is needless. What has been done, therefore, is to make the flanges capable of taking a bolt of diameter equal to three times the flange thickness, with two exceptions noted in their due places.

Definitions.—Fig. 1 is the usual strut chart, with additions, in which average stress at crippling is connected with slenderness ratio. In that figure appear (1) the Euler curve, needing no explanation here; (2) the laboratory curve, commonly known as the strut curve, which gives the results of laboratory tests: it is a conventionalised form of this curve which is commonly used in the design of structures; (3) the secant curve having an eccentricity factor of 0·0025 times the unsupported length of the

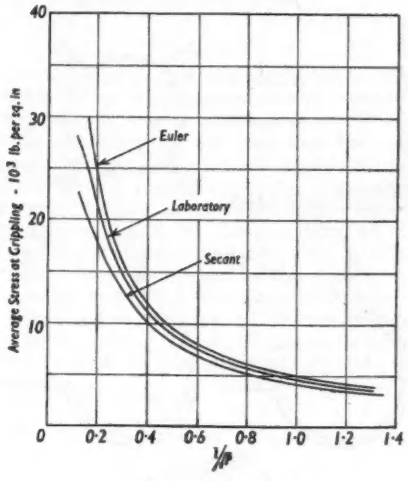


Fig. 2—Efficiency Chart

strut*. For clarity the laboratory curve has been drawn between the Euler and the secant curves. In fact, it may not always so occur and certainly will not when local stress is the decisive factor. The exceptional case, however, need not deter its use. Therefore, failing other means of comparing the value of sections, it is here assumed that the secant curve approximates to the behaviour of a strut forming part of a multi-member structure.

Fig. 2 is an efficiency chart connecting average stress at crippling with length over root load. On it are shown (1) the Eulerian efficiency, obtained by appropriate calculation†: this is the efficiency which would be given by a section of the form being considered on the assumption that it behaves in Eulerian fashion; (2) the laboratory efficiency, which results directly from the laboratory tests, and (3) the secant efficiency given by the secant curve of Fig. 1.

The Sections, Fig. 3

90 *Deg. Angle*†—This is illustrated in Fig. 3 (a) and hereinafter referred to as the "standard angle."

60 *Deg. Angle.*—This section was designed by the method used for the standard angle. Its form is given in Fig. 5. It may be used advantageously for legs in structures triangular in plan, as for instance, masts; but it could be used equally well in transmission line towers, for there is no sufficient reason why such towers should not be triangular in plan: what is needed is reconsideration of traditional practice. This section may also be used for single bracing in any structure.

Channel.—This section, illustrated in Fig. 6

* "The Form of an Aluminium Alloy Angle For Use as a Strut," THE ENGINEER, October 19, 1951.

† Ibid

has a radius of gyration equal in all directions about its centre of gravity. Its use for leg members involves either bent gussets or unsymmetrical construction. There are also bolting difficulties, except in large sizes. Altogether, this section is considered a curiosity. It is included here because even a curiosity may be suggestive.

Re-entrant Angle.—This section combines to an appreciable extent the adaptability of an angle with the efficiency of a tube. Originally its form was as shown in Fig. 7. Its use is illustrated by Fig. 4. It is the root from which the other thin-walled sections described herein have grown, and will now be described in detail: what applies to the one may by easy transition be applied to the others.

The length of the bolting face *b*, Fig. 8, is also the length of the outstanding leg. In all but two of the examples considered here it has been made 9·5. That permits of a bolt of diameter equal to three times the thickness of the flange. That a smaller diameter bolt could be used and that, if it were used, greater efficiency would result, is of no great moment at present, but a greater diameter would be disadvantageous because the material here being considered could not then be developed to its full possibilities, owing to the limitation imposed by the length of the outstanding leg. The fillet radius adopted is 1. No profundity is involved in its choice, not because the author disdains rational proof but because he has none. Simply it is that he feels that it is a suitable radius. ("Feelings" will be dealt with presently.) In the example shown in Fig. 7, the radius at the apex of the knuckle is that of the circle touching the fillet curve and the outsides of the flange and the web. It is by no means certain that so great a thickness at the knuckle is necessary, but no more about that will be said at this point as the matter will recur. The maximum overall width, *Ov*, is over the tips of the flanges. The web is of the same thickness as the flange. The centre of the web circles is at a point which enables the angles to be assembled evenly round a circle when the separation between the flanges is as desired.

Fig. 7

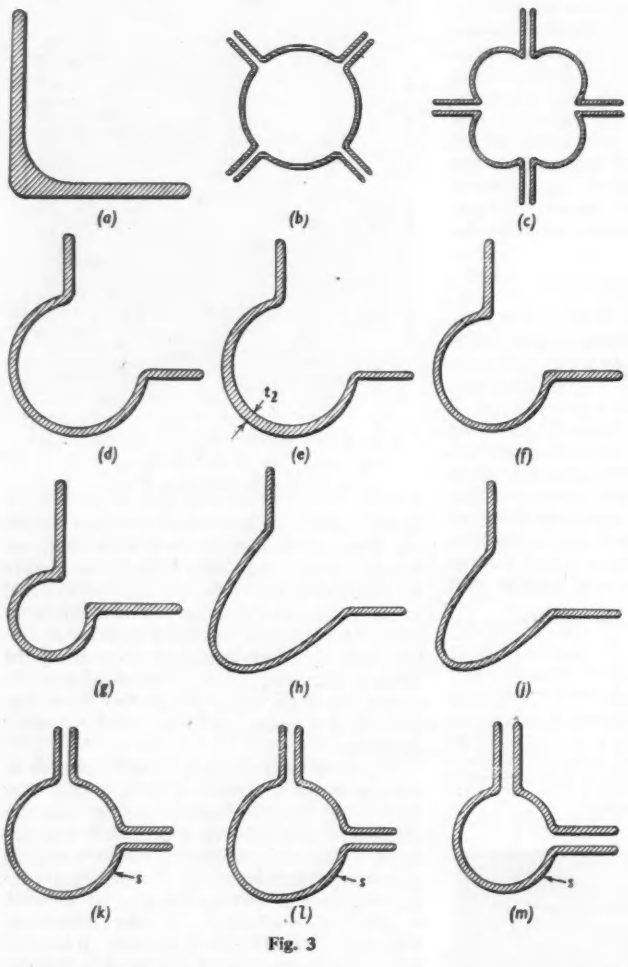


Fig. 3

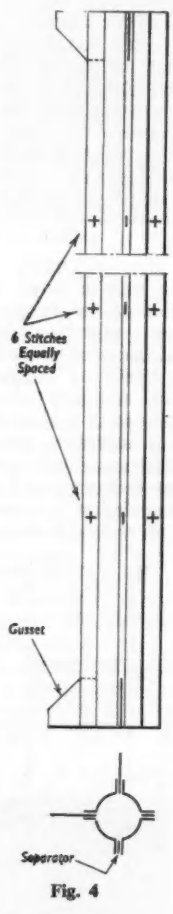


Fig. 4

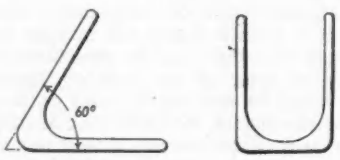


Fig. 5

Fig. 6

The enterprise of the Northern Aluminium Company has led to examples of this section having been made and tested. The particular section dealt with here is of the proportions shown in Fig. 8. That is to say, that the length of the outstanding leg is 8, that the separation is 1, that the section is of uniform thickness throughout, and that the overall width is 35, the maximum permissible. The pertinent results of tests are given in the laboratory efficiency curve of Fig. 9. In that figure also are shown the Eulerian and secant efficiency curves of the same section and, by way of comparison, the secant efficiency curve of the standard angle. The material advantage of the re-entrant angle is clear.

Against that must be set the cost of the stitching needed to make the slenderness ratio of the part just under the slenderness ratio of the whole. But the cost of relatively few stitches would be far from overwhelming. Another disadvantage is the difficulty, when the full strength of the section has to be developed, of splicing. That would be overcome by ingenuity and will, the latter being the essential need, for the means are available.

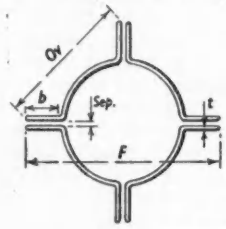


Fig. 8

Salient Angle.—Examples of this section are given in Fig. 3. In that figure (*d*), (*e*), (*f*), (*g*), (k_s) and (m_s), have a circular salient; (*h*) and (*j*) an elliptic salient and (l_s) a salient partly circular and partly elliptic. Further description is needless, but it is to be noted that this section is unsuitable for bracing. To get the best results it would probably be necessary to fix bridges across the gap at each end, and even at one or more points intermediately. That would detract from its overall efficiency. To what extent is a matter for determination when experimental evidence is available.

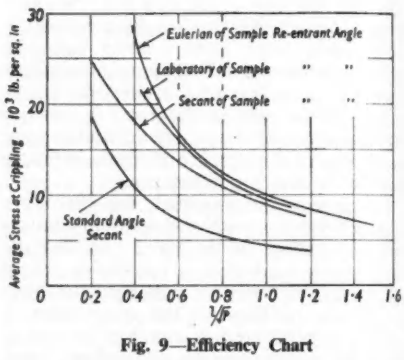


Fig. 9—Efficiency Chart

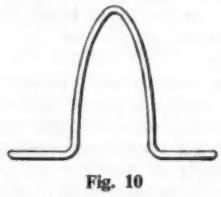


Fig. 10

Composite of Salient and Re-entrant Angles.—Examples are shown in Fig. 3 (*k*), (*l*), and (*m*).

Sombrero Section.—This was derived from the elliptic salient angle, but it may be looked upon as a variant of the top-hat section. The section is intended for bracing and an example is shown in Fig. 10.

Circular Tubes.—It is needless to descant here on the advantage of tubes.‡ To enable

‡ *The Structural Engineer*, February, 1946, page 103.

TABLE I—*Properties of Sections of Unit Area.*

Ref.	Description	Figure	*Ov*	*n*	*b*	Stitches	*t*	*F*	*C*	*r*	r_x	*Z*	Z_x	G_x	$\frac{Z}{r}$
1	90 deg. angle (standard)	3–(*a*)	20·2	1	9·6	—	0·18	2·62	3·64	0·51	0·28	0·27	0·31	0·68	0·52
2	60 deg. angle	5	15·8	1	10	—	0·174	2·60	3·02	0·63	0·70	0·33	0·28	0·64	0·52
3	Channel	6	17·2	2	9·6	—	0·15	2·19	2·59	0·67	=	0·21	0·54, 0·32	0·84, 0·78	0·31
4	Four re-entrant angles	3–(*b*)	35	1	9·5	24	0·077	3·99	2·68	0·99	=	0·50	=	0·077	0·51
5	Four-re-entrant angles	—	35	1	6·5	36	0·078	3·82	2·73	1·09	=	0·57	=	0·078	0·52
6	Salient angle, circular	12	21	3	9·5	—	0·15	3·13	3·49	0·78	0·80	0·46	0·32	0·105	0·59
7	Salient angle, circular	3–(*f*)	28	3	9·5	—	0·129	3·62	3·97	0·90	0·97	0·53	0·41	0·143	0·59
8	Salient angle, circular	3–(*d*)	35	3	9·5	—	0·117	4·08	4·45	1·05	1·16	0·65	0·53	0·174	0·62
9	Salient angle, circular, t_s=2	3–(*e*)	35	3	9·5	—	0·10	3·48	3·79	0·82	0·91	0·4	0·35	0·01	0·49
10	Salient angle, elliptic...	3–(*h*)	35	3	9·5	—	0·119	4·15	4·73	1·09	1·14	0·66	0·48	0·156	0·61
11	Salient angle, elliptic...	3–(*j*)	28	3	9·5	—	0·133	3·72	4·26	0·98	0·99	0·59	0·41	0·272	0·60
12	Salient angle, circular and elliptic	3–(*ls*)	35	2	9·5	—	0·115	4·0	4·42	1·09	=	0·46	=	0·046	0·42
13	Composite circular and elliptic salient, and re-entrant ∠*s*	3–(*l*)	35	2	9·5	8	0·095	3·31	3·61	0·92	=	0·42	=	0·37, 0·11	0·46
14	Composite circular salient and re-entrant ∠*s*	3–(*k*)	35	3	9·5	12	0·096	3·35	3·65	0·96	0·99	0·55	0·49	0·36, 0·17	0·57
15	Composite circular salient and re-entrant ∠*s*	3–(*m*)	28	1	9·5	4	0·109	2·86	3·23	0·70	0·77	0·41	0·33	0·35, 0·13	0·59
16	Sombrero	10	35	1	9·5	—	0·12	4·19	4·41	0·98	=	0·41	0·52	1·06	0·42
17	Circular tube	—	21	—	—	—	0·126	2·65	2·65	0·89	—	0·60	—	—	0·67
18	Circular tube	—	28	—	—	—	0·109	3·04	3·04	1·04	—	0·71	—	—	0·68
19	Circular tube	—	35	—	—	—	0·097	3·39	3·39	1·16	—	0·80	—	—	0·69

Symbols

Ov=maximum overall width of extrusion in terms of *t* (see Fig. 8).
n=number of directions in which *Ov* is present.
b=width of bolting face in terms of *t* (see Fig. 8).
=length of outstanding leg in terms of *t*.
Stitches=number of stitches in unsupported length (see Fig. 4).
t_s=thickness along axis of symmetry in terms of *t* (see Fig. 3).
t=thickness of flange (see Fig. 8).
F=overall width projected on line parallel to bolting face (see Fig. 8).
C=diameter of circumscribing circle of extrusion.
r=least radius of gyration.
r_x=radius of gyration about axis through centre of gravity and parallel to bolting face.
Z=section modulus about axis of least radius of gyration.
Z_x=section modulus about axis through centre of gravity and parallel to bolting face.
G_x=distance from bolting face to axis through centre of gravity and parallel to bolting face.

comparison readily to be made with the sections dealt with herein, the relative values are given in the tables.

COMPARISONS

Eulerian Method.—Table I gives the properties of selected sections. By its means

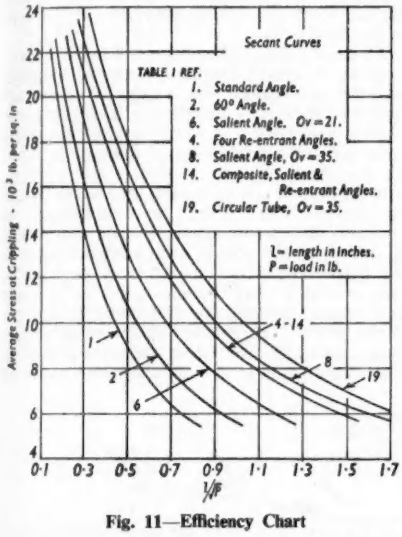

Secant Curves
TABLE I REF.
1. Standard Angle.
2. 60° Angle.
6. Salient Angle. Ov = 21.
4. Four Re-entrant Angles.
8. Salient Angle, Ov = 35.
14. Composite, Salient & Re-entrant Angles.
19. Circular Tube, Ov = 35.
l = length in inches.
P = load in lb.
Average Stress at Crippling · 10³ lb. per sq. in
1/√F

Fig. 11—Efficiency Chart

comparison may be made on an Eulerian basis. Fig. 3 has been drawn to such a scale that each section, as drawn, being of equal length, would support an equal load, strictly on that basis. Figs. 5, 6, 7, 10 and 12 are drawn to a similar scale. In certain cases comparisons would closely approximate to fact, in other cases error might be gross.

Secant Method.—More accurate comparisons may be made by drawing the secant efficiency curves. A representative selection of such curves is given in Fig. 11. But comparison of values made by considering those curves is inconclusive because the distinctive effect of torsion in each section is not taken into account. Experiment is needed to determine what that is. Further help would be welcome.

Aesthetic Method.—In a scientific age it is anachronistic for an engineer to introduce emotional values into his technical work. Nevertheless, he does so here for the reason about to be given.

"Where other means of settling proportions are absent, beauty is a useful guide, for man has so much inbred knowledge, and so much knowledge acquired in so many and so varied ways as to be as unconscious as the inbred, that beauty is not only æsthetic but practical."

Since that was written, twenty-five years ago, further experience has strengthened the opinion. Accordingly, a drawing similar to Fig. 3, but depicting more sections, was prepared. The author looked at it. The first thing to catch his eye was the unsightliness of Fig. 3(*g*). His first impulse was to discard it as useless. But, remembering that a section of relatively low efficiency possesses advantages when minimum thickness is a limit, he looked at it more carefully. He decided that the unsightliness was due largely to the bulges at the knuckles. Therefore, the section was redrawn. It now appears as Fig. 12. Its appearance is much improved. Other alteration does not appear advisable if the limits set for this section, i.e. *Ov* 21, *b* 9·5, and circular salient, are to be kept, for the thickening of any part would lower the Eulerian efficiency. Whether there would be compensating increase of crippling stress is a moot point. It is here assumed that there would be no such compensation. Accordingly, Fig. 12 is taken as definitive.

Again, letting his eye rove over the sections, he perceived that all those sections which have a thickening at the junction of flange and salient are less pleasing than those of uniform thickness. He concludes, therefore, that the thickening has little, if any, value. And he decides, for the present, to make all the sections of uniform thickness.

Then his eye is attracted by the doll-like prettiness of Fig. 3(*c*). The prettiness, however, carries no conviction of strength, so

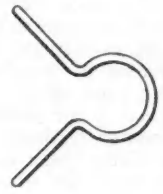


Fig. 12

that it is at least doubtful whether the increase in the maximum possible cross sectional area, or the reduced overall width would result in practical gain. Altogether, this section is deemed a curiosity.

Looking at the whole, the section which most pleases his eye is Fig. 3(*b*). Its simplicity and numerous symmetries doubtless are causes. He thinks, therefore, that the use of this section would give least weight to a structure. But least weight does not necessarily imply least cost. The question, therefore, is still open.

Confining attention now to the two part composite sections, he prefers Fig. 3(*k*) and

TABLE II—*Dimensions of Sections of Selected Thicknesses. Arranged in Order of Eulerian Efficiencies.*

Table I Ref.	Description	*Ef.*	Thickness=$\frac{1}{16}$in			Thickness=$\frac{1}{8}$in			Thickness=$\frac{1}{4}$in			Thickness=$\frac{1}{2}$in			Maximum i.e. circumscribing circle=12in				Use
			A	*r*	Bolt	*A*	*r*	Bolt	*A*	*r*	Bolt	*A*	*r*	Bolt	*t*	*A*	*r*	Bolt	
1	90 deg. angle	100	0·48	0·35	$\frac{3}{4}$	1·09	0·53	$\frac{7}{8}$	1·93	0·71	$\frac{1}{2}$	3·0	0·89	$\frac{11}{16}$	0·593	10·9	1·68	—	*L.B.*
2	60 deg. angle	123	0·52	0·45	$\frac{3}{4}$	1·16	0·68	$\frac{7}{8}$	2·06	0·9	$\frac{1}{2}$	3·2	1·13	$\frac{11}{16}$	0·691	15·8	2·49	—	*L.B.*
15	Composite circular salient and re-entrant ∠*s*	137	1·32	0·8	$\frac{3}{4}$	2·96	1·2	$\frac{7}{8}$	5·26	1·6	$\frac{1}{2}$	8·2	2·0	$\frac{11}{16}$	0·405	13·8	2·6	—	*L.*
6	Salient angle...	153	0·7	0·65	$\frac{1}{2}$	1·57	0·98	$\frac{5}{8}$	2·8	1·3	$\frac{3}{8}$	4·37	1·63	$\frac{11}{16}$	0·514	11·8	2·68	—	*L.*
17	Circular tube (swaged ends) ...	175	0·99	0·89	$\frac{1}{2}$	2·22	1·33	—	3·94	1·77	—	6·15	2·21	—	0·571	20·5	4·04	—	*B.*
7	Salient angle...	176	0·94	0·87	$\frac{1}{2}$	2·11	1·31	$\frac{5}{8}$	3·76	1·74	$\frac{3}{8}$	5·9	2·18	$\frac{11}{16}$	0·39	9·1	2·72	—	*L.*
13	Composite circular and elliptic salient and re-entrant ∠*s*	181	1·75	1·22	$\frac{3}{4}$	3·93	1·83	$\frac{7}{8}$	7·0	2·44	$\frac{1}{2}$	10·9	3·04	$\frac{11}{16}$	0·315	11·0	3·07	$\frac{11}{16}$	*L.*
14	Composite circular salient and re-entrant ∠*s*	188	1·7	1·25	$\frac{3}{4}$	3·82	1·87	$\frac{7}{8}$	6·8	2·5	$\frac{1}{2}$	10·6	3·12	$\frac{11}{16}$	0·316	10·8	3·16	$\frac{11}{16}$	*L.*
4	Four re-entrant angles	194	2·6	1·61	$\frac{3}{4}$	5·9	2·41	$\frac{7}{8}$	10·5	3·21	$\frac{1}{2}$	16·5	4·02	$\frac{11}{16}$	0·345	20·6	4·43	—	*L.B.*
18	Circular tube (swaged ends) ...	204	1·33	1·19	—	3·0	1·79	—	5·3	2·39	—	8·3	3·0	—	0·429	15·6	4·29	—	*B.*
11	Salient angle...	206	1·14	1·12	$\frac{3}{4}$	2·6	1·68	$\frac{7}{8}$	4·6	2·24	$\frac{1}{2}$	7·1	2·8	$\frac{11}{16}$	0·316	7·3	2·83	$\frac{11}{16}$	*L.*
5	Four re-entrant angles	214	2·6	1·75	$\frac{1}{2}$	5·8	2·62	$\frac{5}{8}$	10·3	3·49	$\frac{3}{8}$	16·1	4·37	$\frac{5}{8}$	0·343	19·3	4·79	$\frac{11}{16}$	*L.B.*
12	Salient angle, circular and elliptic	214	1·18	1·18	$\frac{3}{4}$	1·63	1·76	$\frac{7}{8}$	4·72	2·35	$\frac{1}{2}$	7·36	2·94	$\frac{11}{16}$	0·313	7·38	2·94	$\frac{11}{16}$	*L.*
19	Circular tube (swaged ends) ...	228	1·67	1·50	—	3·75	2·25	—	6·7	3·0	—	10·4	3·75	—	0·342	12·5	4·11	—	*B.*

Symbols

Ef.=percentage Eulerian efficiency relative to standard angle.
A=cross-sectional area in square inches.
r=least radius of gyration in inches.
Bolt=maximum permissible diameter of bolt in inches, when less than 1in.
t=thickness in inches.
L=suitable for legs.
B=suitable for bracing.

(*l*) to (*m*), but finds it difficult to decide which of the two is the more pleasing. He, therefore, turns to the secant efficiency curves of those sections and finds that they almost coincide and cross at a slenderness ratio of 80. There is, however, a deciding factor : Fig. 3 (*k*) is the simpler. That, therefore, is chosen as the best two-part composite section.

Considering now only the fully-open sections, Fig. 3 (*d*) and (*h*) are more pleasing than the others and their Eulerian and secant efficiencies are not vastly different. The elliptic salient, however, makes one wonder whether the mutual support given by the two parts meeting at the knuckles is enough to prevent local failure. Accordingly, (*d*) is chosen as the best fully-open section.

There are, therefore, three sections, Fig. 3 (*b*) (*d*) and (*k*) competing for first place. There is not sufficient reason to suppose that (*k*) would not behave substantially as calculated. Therefore, and because of the fewer stitches needed, it is preferred to (*b*) ; and, because it is more convincing, owing to the mutual support of the two parts, it is preferred to (*d*). But, because of the prospect of economic advantage, due to absence of stitches and a "get-at-able" inside, (*d*) is the one which should be tested first.

But there is advantage, already mentioned, in having a section of relatively great thickness, even if its efficiency is not of the highest. It would be well, therefore, to experiment also with Fig. 12 section before deciding what next to do.

Range of Use.—Table II has been prepared in order to bring out the range of usefulness of representative sections. From the table, it is clear that in lands where safety is a mania and the engineer is restricted to minimum thicknesses imposed by cautious authority, the use of the more efficient sections is extremely limited. For instance, where $\frac{5}{16}$in is the minimum permissible thickness, section Ref. 5, Table I, can be used at its maximum efficiency only when the cross-sectional area is from 16·1 to 19·3 square inches (see Table II), which rules it out for any but a substantial structure ; whereas, in lands where safety rules are less restrictive enterprise is free and judgment unfettered, scope abounds for the use of the most economical section for almost any purpose.

Conclusions

The experimental background justifies the use of the standard angle without more ado. Further experiment might lead to modification. The parallelism between the 60 deg. angle and the standard angle justifies the use of the former without other than engineering risk. The experimental results justify the use of re-entrant angles with an overall of 35 and an outstanding leg of 8.

For the rest, all is speculative. Experiment is needed. When experiment in the desired direction will take place cannot reliably be forecast. Hence this record.

Performance and Efficiency Tests on the "Britannia" Locomotives

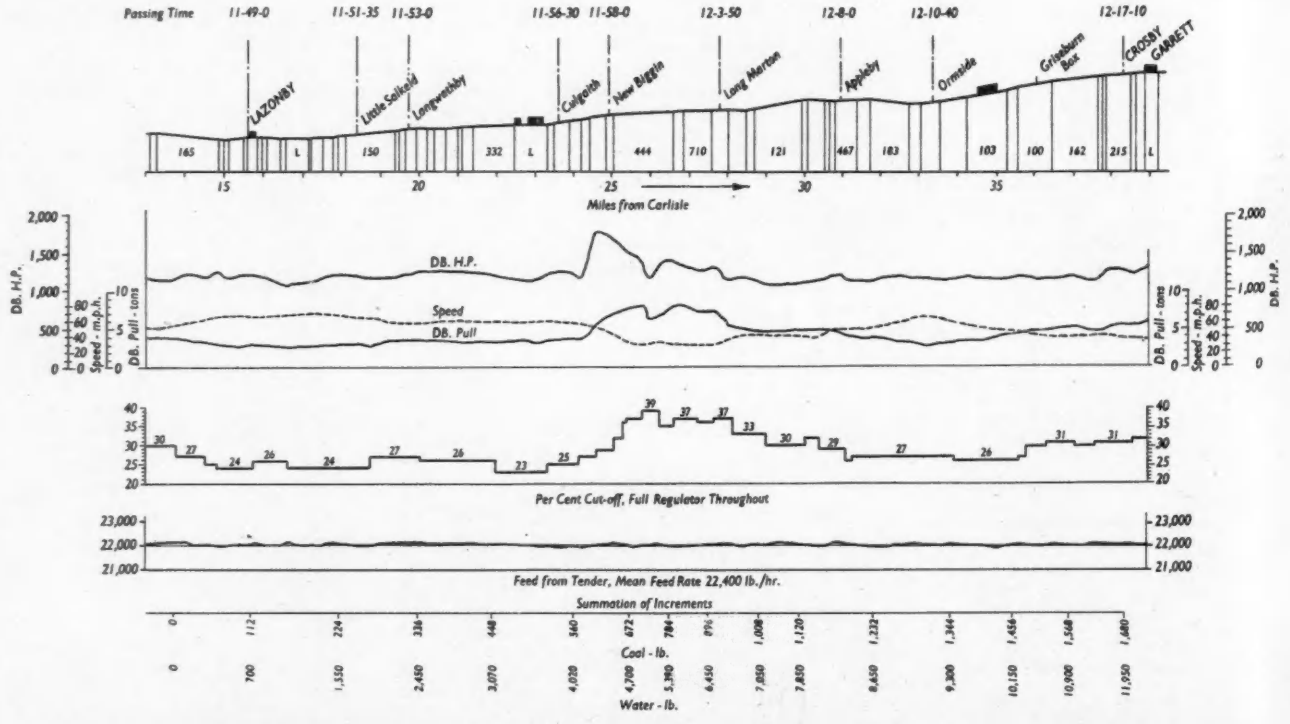
By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. II—(*Concluded from page* 104, *July* 24*th*)

Since the Railway Executive inaugurated the practice of publishing bulletins containing complete details of full-dress thermodynamic trials on modern locomotives, no test results have been awaited more keenly than those from the new British Standard "Pacifics" of the "Britannia" class. These details have now been published, and in this article and the previous one the author reviews this bulletin and analyses some of the results.

IN the first article dealing with tests on the "Britannia" locomotives, the performance of the boiler and the indicated horsepower characteristics were discussed. They are quantities capable of direct measurement and verification on the stationary testing plant in stable, closely controlled conditions. But while such results are of the greatest importance to locomotive engineers, and all concerned with the scientific development of this old, yet extremely virile, form of motive power, it is the interpretation of those results in the terms of weight-hauling ability, at varying speeds, and over a full range of adverse gradients, that is of the first importance to the traffic department. The present bulletin, like previous ones of the series, not only gives the anticipated performance of the "Britannia" locomotives, but presents the graphs in such a way that the most economical speeds can readily be seen in any conditions of train loading. These very useful graphs are derived from the drawbar horsepower characteristics of the locomotive, which were in turn derived from the results obtained on the controlled road tests.

All graphs designed to assist the traffic department in this use of locomotives should naturally give the performance that is expected in average running conditions—neither too favourable, nor unduly pessimistic ; it would not be reasonable in laying down limitations of tonnage to allow for the effects of a heavy adverse gale of wind, since in normal conditions the locomotive would be underloaded. Thus, in establishing the drawbar horsepower characteristics there must be added, to the precise measurements made in the dynamometer car, a degree of experienced judgment in settling the allowances to be made as a general average, for direction and strength of the wind. This might perhaps be subject to local allowances over routes where the prevailing wind is markedly in one direction, and based on



Dynamometer car test No. 1032, February 4, 1952. Blidworth coal, 12,600 B.Th.U. per pound as fired. Exhaust steam injector supplemented by live. Load 468 tons, including two mobile testing units. Approximate equivalent load 540 tons. Water rate 22,400 lb per hour (feed from tender). Coal rate 3360 lb per hour (inclusive of requirements of auxiliaries).

Fig. 5—Example of Test at Constant Evaporation under Conditions Giving Approximately Most Economical Coal Consumption

the accumulated experience over many years of the Region concerned. The controlled road tests were carried out on engine No. 70005, over that most famous of Midland trial routes, the Settle and Carlisle line. They were of particular interest in that two of the L.M.S. mobile testing units were included in some of the trains to provide additional load without the need for conveying extra coaches, and the difficulty of maintaining vacuum with the standard type of ejector throughout an abnormally long train. This use of the mobile test units was carried to such an extent on one maximum power test that an equivalent load quoted as approximately equal to 850 tons was hauled over the adverse gradients between Lazonby and Crosby Garrett, whereas the normal maximum tonnage for a class "7" engine in ordinary service is 405 tons.

In view of the fine indicated horsepower characteristics illustrated in Fig. 4 of the previous article it is of interest to compare some of the corresponding drawbar horsepower values presented in the report. In the following table the figures for 30 per cent cut-off at varying speeds are set out; from these have been deduced the "frictional" horsepower and the relevant total engine resistance:

Class "7" 4–6–2 Engine: 30 Per Cent Cut-Off: South Kirkby Coal

Speed, m.p.h.	I.h.p.	D.b.p.	F.h.p.	Total engine and tender resistance, pounds per ton
20	860	730	130	17·1
30	1170	965	205	17·9
40	1450	1160	290	19·0
50	1690	1300	390	20·3
60	1880	1410	470	20·6
70	2030	1455	575	21·6

By standards previously accepted there is no doubt that the figures of engine resistance contained in the above table are exceptionally low, particularly in the manner that they show an almost straight line characteristic. Earlier bulletins published by the Railway Executive relating to new standard locomotives and to certain Regional locomotives show a characteristic curve rising sharply at higher speeds, in general conformity with various empirical formulæ for engine resistance, compiled by earlier experimenters, such as the late Sir John A. F. Aspinall. It is generally known, too, that the factor contributing most at higher speeds is not any characteristic of the engine machinery, but the resistance of the wind. This makes the "Britannia" figures the more remarkable, in that the locomotives are devoid of any form of streamlining. Comparative figures for engine resistance calculated from data presented in previous bulletins are:

Resistance in Pounds per Ton

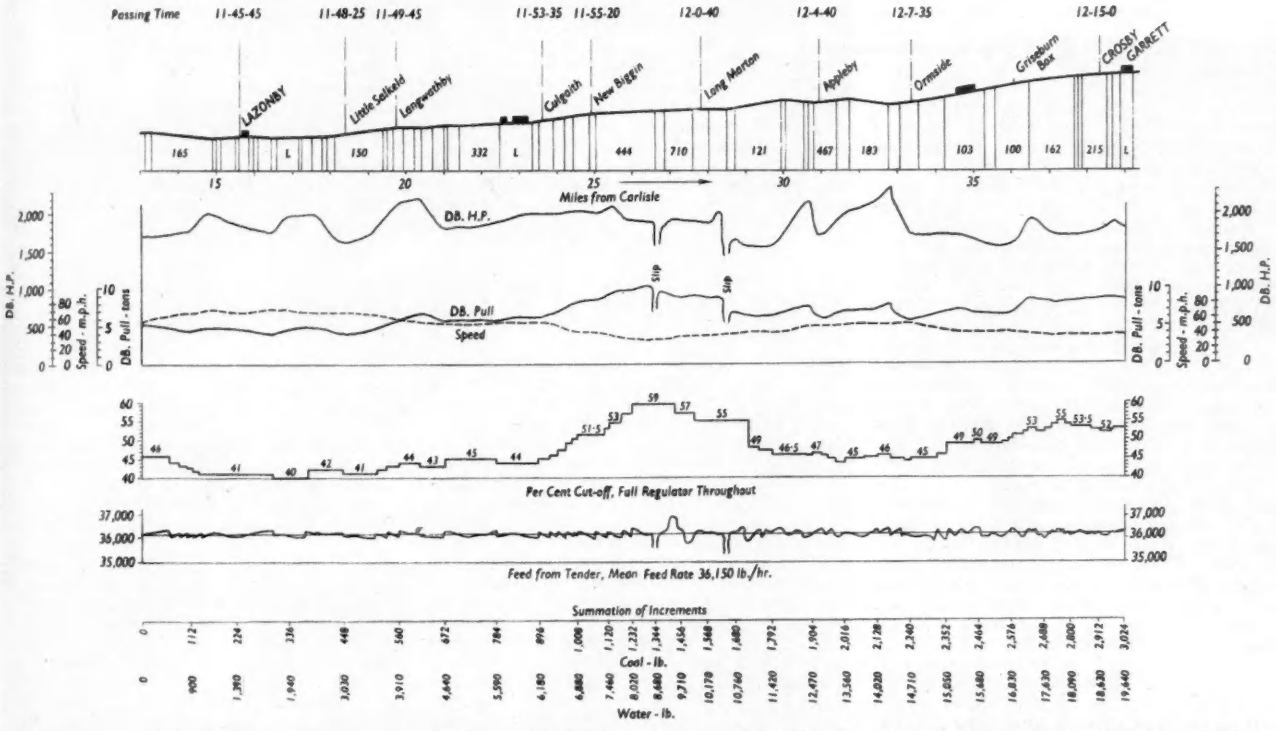
Speed	Standard class "4," 4–6–0	W.R. class "5," "Hall"	Standard class "7," "Britannia"
30 m.p.h.	17·0	18·3	17·9
40 m.p.h.	18·3	19·8	19·0
50 m.p.h.	20·4	20·7	20·3
60 m.p.h.	23·4	24·4	20·6
70 m.p.h.	28·0	30·5	21·6

These figures are necessarily approximate, as the values of indicated horsepower and drawbar horsepower have been read off the small-scale curves in the bulletin. But they are sufficient to show the general order of the resistances.

Coming now to actual performance under controlled road-testing conditions, Fig. 5 shows a portion of a run southbound from Carlisle to Skipton in which the steaming was maintained at about the maximum one might expect in heavy present-day traffic conditions. The equivalent load behind the tender, allowing for the effect of the two mobile test units, is quoted as 540 tons, and the feed from the tender was 22,400 lb per hour. The average speed over the generally adverse length shown in the diagram was 49·2 m.p.h., including a heavy slack to about 30 m.p.h. for 2 miles in the neighbourhood of Long Marton. Here the necessary reduction of speed was made by braking and the engine cut-off was increased step by step from 23 to 39 per cent to maintain the constant rate of steaming. Blidworth coal was being fired, and at this rate of working the indicated horsepower varies between 1600 at 30 m.p.h. to nearly 1800 at 60 to 70 m.p.h. The boiler efficiency is approximately 72 per cent and the coal rate is a little under 3 lb per drawbar horsepower hour. The engine showed a very comfortable mastery over this heavy train even though Grade 2B coal was in use, on what would be regarded, in ordinary service, as a crack working.

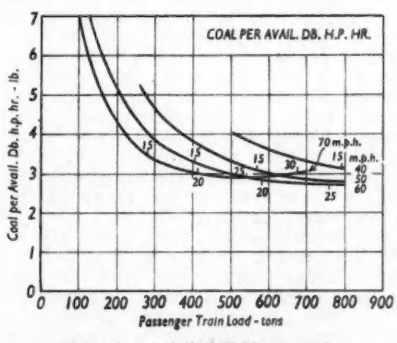
As a result of both stationary and road tests the bulletin sets out certain limits for the boiler, reproduced in Table II below.

The bulletin does state, however, that the figure given for the limit of one fireman should be regarded as a purely arbitrary one, depending on the particular engine, and on the time factor. Care must also be taken in applying the coal rate quoted of 3000 lb per hour. This would be equal to approximately five shovelfuls per minute. This would have to be kept up continuously, if the steam rate is to be maintained, and there are, of course, other duties which a fireman is expected to perform when the locomotive is in traffic. The estimated limit of 3000 lb per hour—equal to 60 lb per train-mile on a service booked at 50 m.p.h.—has frequently been exceeded in the past on locomotives of older design with small, deep fireboxes. It is



Dynamometer car test No. 1040, February 15, 1952. South Kirkby coal, 14,000 B.Th.U. per pound as fired. Exhaust steam injector, supplemented by live. Load 430 tons, including two mobile testing units. Approximate equivalent load=850 tons. Water rate 36,150 lb per hour (feed from tender). Coal rate 5600 lb per hour (inclusive of requirements of auxiliaries).

Fig. 6—Example of Run at Constant Evaporation at High Steaming Rate

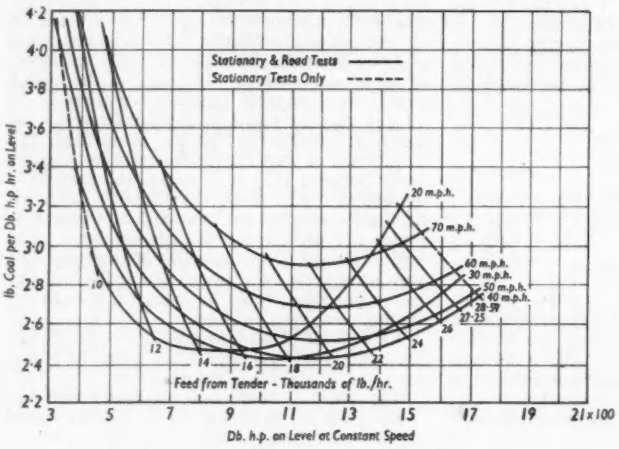


Blidworth coal, 12,600 B.Th.U. per pound.
Figures on curves indicate cut-off, maximum steam chest pressure.

Fig. 7—Consumption of Coal at Various Passenger Train Loads on Level

TABLE II—*B.R. Standard Class "7": Boiler Limits: Sustained Rates*

	Limit of exhaust steam injector	Estimated limit for one fireman	Maximum attained on test plant	Front end limit
South Kirkby Coal: C.V. 13,800 (B.Th.U. per pound):				
Feed water, lb/hr ...	22,000	23,100	30,200	—
Steam, lb/hr	23,410	24,510	31,610	—
Coal, lb/hr	2,813	3,000	4,320	—
Blidworth coal: C.V. 12,600 (B.Th.U. per pound):				
Feed water, lb/hr ...	22,000	19,800	—	30,000
Steam, lb/hr	23,410	21,060	—	31,410
Coal, lb/hr	3,411	3,000	—	5,066



Blidworth coal, 12,600 B.Th.U. per pound.

Fig. 8—Coal per Drawbar-Horsepower-Hour

one thing to stoke a London and North-Western "George the Fifth" class 4-4-0 at a rate of 120 lb to 130 lb of coal per square foot of grate area per hour—2700 lb to 3000 lb per hour—but quite another to keep a wide, modern grate of 40 to 50 square feet covered in a manner calculated to secure maximum steam production.

With such a willing hard-working engine as a "Britannia" there is a natural temptation to try and extract the very last ounce in a road test, and a further trial, details of which are reproduced in Fig. 6, must represent something very near it. Using two firemen, and working the coal rate up to the phenomenal sustained figure for a modern English locomotive of 5600 lb per hour (133 lb per square foot of grate area per hour), a water rate of 36,150 lb per hour was recorded. This was considerably in excess of the maximum reached on the Rugby plant. In studying the details of Fig. 6 one recalls instinctively a humorous remark made by Mr. Riddles when representatives of the technical Press were at Rugby in 1951 and this very engine, No. 70005, "John Bunyan," was on the plant. A run at high capacity was about to begin, and he turned to those of us nearby and said: "Now we're going to try and break it!" It might well seem from the details of Fig. 6 that those running the trial had received instructions in a similar vein. Unfortunately, the engine was not indicated, but the diagram shows several peaks in the drawbar horsepower that are considerably above 2000. South of Culgaith the cut-off was never less than 44 per cent, with full regulator, and there must have been times when the indicated horsepower was around 2500 or 2600. The present reviewer has seen a "Britannia" locomotive worked at 30 to 40 per cent for about 15 min on end, in Cornwall; but this was at speeds mostly below 40 m.p.h. On the 850-ton test from Carlisle No. 70005 was worked at 45 to 49 per cent for considerable stretches at over 50 m.p.h. From the diagram the average drawbar horsepower would appear to be some 1800–1900, and against a coal rate of 5600 lb the consumption per drawbar horsepower hour, even with such "all-out" flogging, was no more than 3 lb. This compares with the 2·2 lb to 2·6 lb under normal express passenger conditions. These coal rates refer to South Kirkby coal.

While a sustained effort of this kind is, of course, far beyond anything that would be contemplated, for one moment, in normal service, the tractive capacity of the engine has been demonstrated. If some driver chose to flog a "Britannia" even briefly in comparable style it would in all probability be at the expense of mortgaging the boiler, temporarily, and tearing the fire to pieces. Ordinary conditions would not call for the body of the fire necessary for an effort like that shown in Fig. 6. But it is certainly useful to know that the engines will take such a flogging. Another factor in connection with this "all-out" trial is of considerable interest, namely, that twice in the course of the run the limit of adhesion was reached. The first instance came when the drawbar pull at 30 m.p.h. was 10 tons, and still rising, and the cut-off was 59 per cent with full regulator. The second instance was at 8½ tons drawbar pull, speed 40 m.p.h., and cut-off 55 per cent. No mention is made in the bulletin of the rail conditions on this trip, but in general the "Britannias" and the smaller standard "Pacifics" of the "Clan" class seem to be rather better than most British "Pacifics" when fighting a heavy grade in adverse conditions. Occasions come to mind with "Pacifics" of former L.M.S., L.N.E.R. and Southern designs in which the tractive effort and the high steaming capacity of the boiler was rendered of little value due to continuous and severe slipping.

The diagram reproduced in Fig. 6 is deserving of close study on another account, namely, the way in which the electrical load provided by the mobile test units was varied in order to prevent the speed rising too high. The downhill stretch graded at 1 in 183 just south of Appleby is a case in point. This place is usually the last respite before the final ascent to Aisgill, and even with the steaming of the locomotives eased speed often rises to 70 m.p.h. near Ormside. On the test, however, the electrical load was evidently increased, as the driver had to lengthen his cut-off from 45 to 4 per cent, and the drawbar horsepower rose, on a downhill stretch, from 2000 to a sharp peak of 2400. At the same time, in the absence of all the relevant data, the diagram reproduced in Fig. 5 does not entirely explain the fluctuations in drawbar pull, and especially the very sharp peaks in the graph of drawbar horsepower. An increase of no more than 1 per cent in the cut-off, with practically no change in the speed, seems unlikely to cause so large and rapid an increase in power. The performance on this special run was beyond anything run steadily on the test plant, and so the work cannot be related to the curves of performance included elsewhere in the bulletin. The basic coal consumption figures of the engine up to a maximum of about 30,000 lb of steam per hour are shown in Fig. 6. Of the two diagrams included in the bulletin that relating to Blidworth coal has been chosen as indicating the likely performances on something less than the best quality of coal. Figs. 7 and 8 show these coal consumptions related to trains of varying weight, and as a measure of the efficiency and traffic capacity of the new engines these results are certainly excellent.

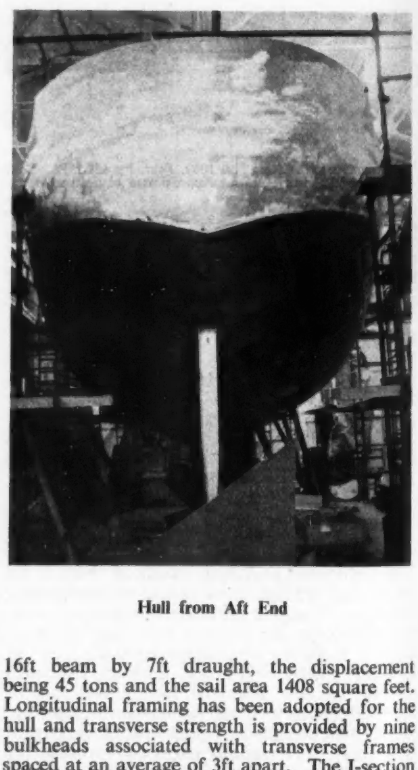
Welded Light Alloy Yacht

ONE of the factors militating against the greater use of aluminium alloys in ship and boat building has been the difficulty in producing sound welds owing to the presence of aluminium oxide on the surface of the material. This tendency of aluminium to oxidise has a profound effect in welding since the film of oxide is continuous and thickens as the temperature rises and, as the melting point of aluminium oxide is about 2000 deg. Cent., it does not dissolve in liquid aluminium. To remove the film a flux has to be used and to ensure a good weld it is essential not only to make certain that the slag formed by the reaction between the oxide and the flux is not entrapped, but that all flux residues are removed since they are liable to corrode the metal. The introduction of the argonarc welding process, in which a shroud of inert gas covers the weld pool and prevents oxidation without the use of flux, has solved most of the problems in the production of a sound weld. A further developments of the argonarc process has been the introduction of the self-adjusting arc process, known as "Aircomatic" in the United States and manufactured in this country by the British Oxygen Company, Ltd., under the name of "Argonaut." In this system the tungsten electrode of the argonarc process is replaced by a consumable electrode consisting of a filler rod which is fed automatically through the barrel of the welding gun at a rate regulated according to the thickness of the work.

Very little work has been done on the welding of aluminium alloys in the shipyards, and with the object of providing a practical demonstration of the use of the self-adjusting arc process in ship construction the British Aluminium Company, Ltd., is having built a motor yacht. It is a 72ft auxiliary motor yacht named "Morag Mhor," which has been designed by Laurent Giles and Partners, Ltd., in conjunction with Saunders-Roe (Anglesey), Ltd., and is being built at the Beaumaris yard of the latter company. The hull, which has scantlings comparable with those used for the deckhouses of ships, is being welded using the American "Aircomatic" and the British Oxygen Company's "Argonaut" equipment.

The physical and economic advantages of using aluminium alloys for boat building are well known and appreciated, and compared with the boat of normal wooden construction the hull will remain watertight during the season and after the winter lay-up. There will be no need for recaulking and the hull will not increase in weight, over the years, due to absorption. The adoption of welding will show a saving on first cost over riveted construction by the elimination of plate overlaps, wide flanged sections and the reduced amount of work involved in the preparation of plates and sections.

The yacht has a length overall of 72ft 3in and a length on the datum waterline of 60ft 4in by



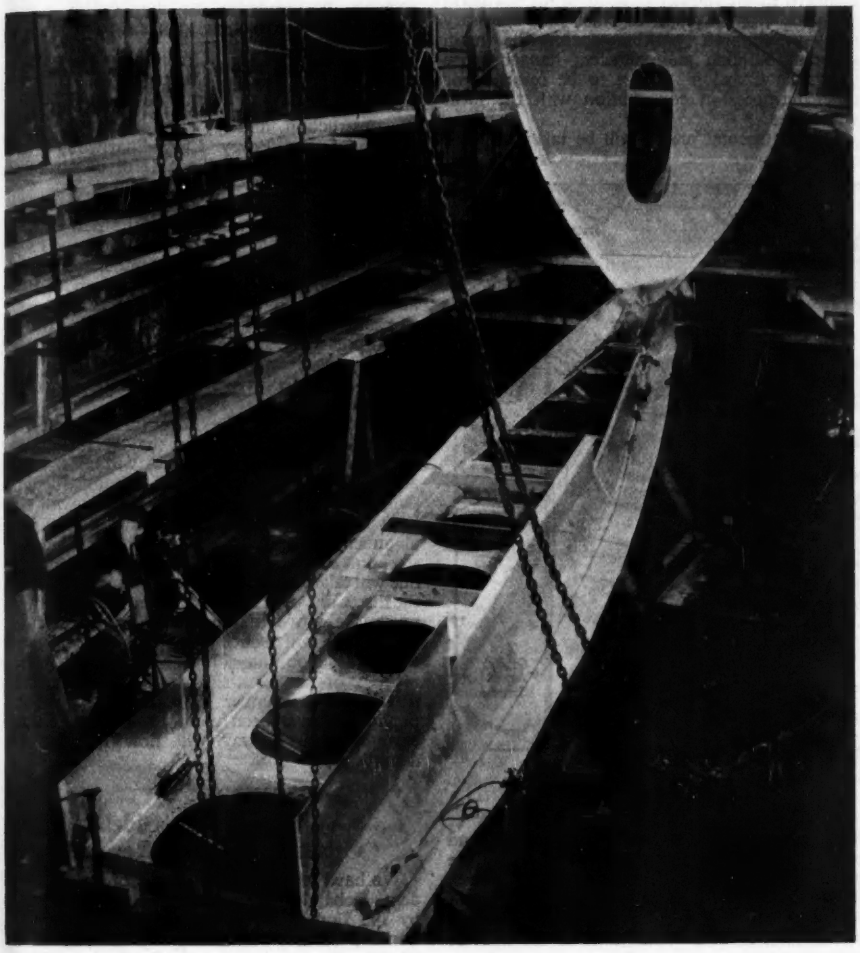
Hull from Aft End

16ft beam by 7ft draught, the displacement being 45 tons and the sail area 1408 square feet. Longitudinal framing has been adopted for the hull and transverse strength is provided by nine bulkheads associated with transverse frames spaced at an average of 3ft apart. The I-section longitudinal frames of 1⅜in by 1⅜in by $\frac{3}{16}$in scantling are spaced approximately 14in apart and are welded directly to the hull plating which is generally $\frac{5}{16}$in thick, and arranged with the

seams to follow the line of the longitudinal frames of which there are ten on each side of the ship so that they act as backing bars. Similarly, the butts have been arranged to fall on the bulkhead boundary bars. The longitudinal frames, which are continuously welded to the shell at the seam and intermittently welded elsewhere, are continuous, the inner flange being tapered off in way of bulkheads and the connection reinforced by a gusset plate, while the transverse framing of 1½in by 1in by 0·1875/0·125 channel section is not connected to the shell, but to the inboard flange of the longitudinals. Channel sections and top-hat sections are used as bulkhead stiffeners.

A box-shaped fin, which is of streamline form tapering towards the stem and merging into the contour stem plate, forms the centre strake 0·125in thick and stringer plates 0·25in thick.

A double plate welded rudder of streamlined horizontal section is hung abaft a plate skeg which forms the rudder post and tapers forward to a thin section at the leading edge. The main and mizzen masts are fabricated and are formed by welding together two plates which have been rolled to half-section profile, to form an oval cross section. There is a longitudinal butt weld on each side of the masts which are built in sections about 10ft in length and joined by circumferential butt welds. Plate 0·25in thick is used for the main mast, which is of 14in by 11in section tapering to 6½in diameter at the truck and 70ft long, while the mizzen is constructed of 0·20in plating forming a 10in by 8in section tapering to 5in diameter and is



Double Bottom Assembly

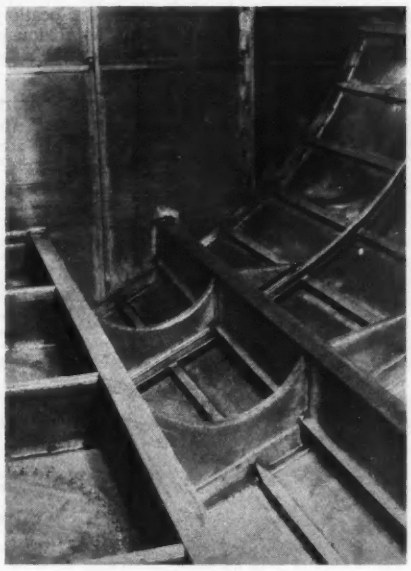
keel, and consists of a ¾in thick flat plate keel and ⅜in thick keel side plates joined together by a specially extruded section. The keel is divided longitudinally by floor plates at each transverse frame and bulkhead, and is also divided into upper and lower sections. Cast iron ballast coated with bituminous solution is stowed in the lower half, and being isolated from salt water there is no danger of any electrolytic action taking place. The upper part of the fin and double bottom are arranged for the carriage of fresh water and large bolted cover plates in the tank top plating, which is 0·20in thick, give access to the tanks, and similar cover plates in the tank bottom plate give access to the ballast. The garboard strake is ½in thick and there is a radiused gunwale plate over the midship length, of the same thickness, but of flanging quality plate, butt welded to the sheer strake and the deck stringer plate. Longitudinal framing has also been adopted for the deck, the longitudinals consisting of 1¾in by 1¾in by $\frac{5}{16}$in channels associated with transverse beams of the same scantling. The deck plating has a wide centre

46ft 6in in length. Both masts are stepped on the deck. The superstructures are of riveted double skin construction with stiffeners acting as spacing members between the outer skin of 16 S.W.G. and the inner skin of 18 S.W.G. sheet material.

The constructional material has been supplied by the British Aluminium Company, Ltd., and the hull plating generally conforms to standard specification NP5/6, and is of flanging quality where required, while the sheet material is NS6 aluminium alloy in the one-quarter hard condition. The sections used are extruded in N.E.6 and the rivets are to N.5 composition, while the filler wire used for welding has a 5 per cent magnesium content produced to specification NW.6.

Our illustrations reproduced herewith give a general view of the hull looking from aft, and show the construction of the double bottom. The illustration of the machinery space shows the general construction of the hull, engine bearers and the tank top.

The boat is arranged with a raised wheelhouse, just forward of the mizzen mast, from which steps to starboard lead down to a lobby with the galley arranged to port. Further forward is a spacious saloon with a stairway leading down to the forward accommodation which consists of two single-berth cabins and a double cabin. Access to the aft accommodation consisting of one single cabin and a large double cabin is by means of a stairway from the lobby from which a door to starboard opens directly on to the deck. There is a large fore peak and a large capacity store aft and arranged to be stowed on the after deck are a 12ft launch fitted with 4 h.p. Stuart Turner motor and a 10ft sailing dinghy, both of welded aluminium alloy construction. Access to the engine-room is by vertical ladder from the wheelhouse, the aft end of the space is occupied by the quarters for the crew, and at the forward end are two Gleniffer "DB.6" diesel engines, each rated to develop 72 b.h.p. at 1000 r.p.m. They drive 26in diameter three-bladed variable propellers, supplied by Slack and Parr, Ltd., and are directly controlled from the



Engine Bearers

wheelhouse. A closed circuit cooling water system is employed and the water is cooled in specially constructed surface cooling tanks built on to the shell adjacent to the engines. A total of 800 gallons of fuel is carried in built-in tanks arranged to port and starboard in the engine-room. A 3kW generator is driven by a twin-cylinder Stuart Turner diesel engine.

The "Gyron" Turbo-Jet Engine

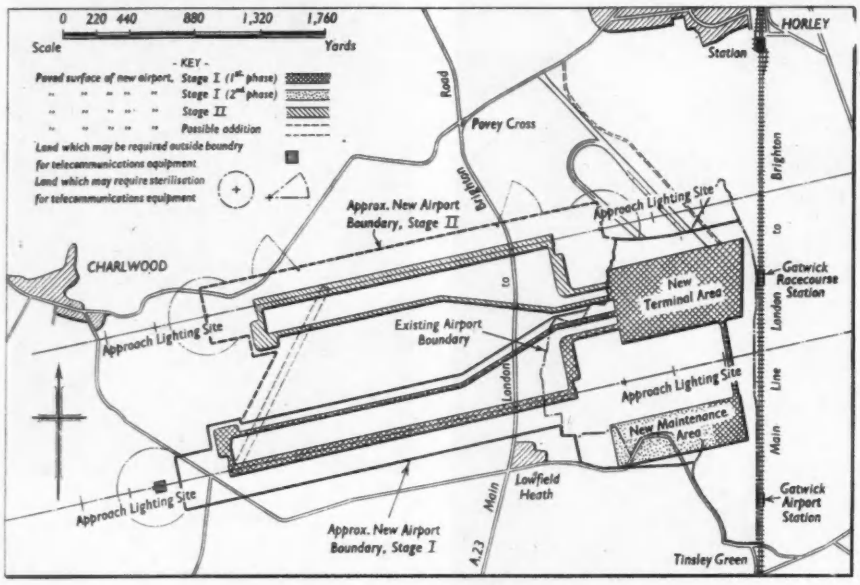
It has been announced by the de Havilland Engine Company, Ltd., that it has been engaged secretly for the last three years on an axial-flow jet turbine known as the "Gyron." It is stated that although its design thrust or any other detail of the engine cannot be disclosed the company has no knowledge of any prototype engine in the world with the same thrust potentiality. It is described as having exceptional simplicity and low weight and has given over a substantial period a thrust greater than announced for any other engine. Development of the engine first started as a private venture, but it is now being developed under Ministry of Supply contract for use, it is stated, for supersonic fighter aircraft.

It may be made known that the "Gyron" was giving very high thrust within the first few weeks of its running and that it has given satisfactorily low specific consumptions and a high degree of reliability. The time and cost involved in engine development—greater than in aircraft development—make necessary the exercise of very careful judgment and foresight to determine the size of engine that will be in demand five to fifteen years ahead, and the design features and materials which can be employed at that period.

Gatwick Airport Development

LAST week the Minister of Transport and Civil Aviation, Mr. Lennox-Boyd, disclosed in the House of Commons the detailed modifications to the proposed development of Gatwick Airport, which was first announced in the House a year ago. The original scheme was published as a memorandum last October, much of which was reproduced in our issue of October 17th. It had then been submitted to various parties affected by the extension and the modifications which are described herewith are the outcome of their representations to the Minister and subsequent discussions. In addition, further consideration has been given, at the request of the Railway Executive, to the siting of the runways relative to the very busy stretch of the electrified London/Brighton line, which forms the eastern boundary to the aerodrome.

The revised layout is shown on the attached plan. The details of boundaries and the location of telecommunication facilities are approximate only and are subject to further survey ; the taxiway layout may also be subject to change. Details of the maintenance area and the terminal area have been omitted.



Modified Arrangement of Proposed Airport Layout

Revised Layout

As in the original proposals, the developed airport would have two main runways parallel to each other with a passenger terminal and an aircraft maintenance area. There might also be a third, subsidiary, runway lying N.E.-S.W. if it proved to be necessary. The two main runways would remain on approximately the same general E.-W. orientation which is dictated by ocal conditions, but would differ from the original proposals in the following respects : the eastern end of the northern runway would be 2900ft and that of the southern runway 2200ft further to the west ; both runways would be swung counter clockwise through 5 deg. as compared to the original line ; the southern runway would remain 7000ft long but the northern would be shortened from 7000ft to 6000ft ; and the distance between the two runways would be reduced from 3200ft to 3000ft. The subsidiary (N.E.-S.W.) runway would be 4000ft instead of 5000ft long and it would be 2900ft further to the west.

The terminal building and aircraft parking aprons would, as in the original plan, be sited close to Gatwick Racecourse station, but the displacement of the runways will permit the new hangar and workshops to be sited rather over a quarter of a mile further to the north than under the original scheme, and a maintenance area has been designed in the south-east corner of the airport to the north of the existing maintenance area. The existing hangars will, however, have to remain in use for some years to come.

Stages of Development

It is now planned to develop Gatwick in two main stages, observing two phases during the first stage

Stage I (first phase) involves construction of the southern E.-W. runway (instead of the northern, as in the original plan), together with necessary taxiways, aircraft parking space, the main terminal building and sufficient hangar space to enable Croydon Airport to be released for other purposes in consultation with the local authorities.

Stage I (second phase) will be taken up with the development of the maintenance area and other facilities needed at Gatwick as part of the plan to close Stansted and Bovingdon Airports. If it is needed, the subsidiary (N.E.-S.W.) runway would be built during this stage. A decision on this point will be taken later in the light of experience of technical developments in the cross-wind landing characteristics of small transport aircraft likely then to be in use.

Stage II will involve construction of the northern runway, additional taxiways and aircraft parking space, if these became necessary.

Phasing of Development.—Stage I (first phase) : the aim is to complete the construction of all but the hangars by 1958, by which time a road would have been provided to replace the section of the main London-Brighton road (A.23) severed by the construction of the runway. The hangars will be completed shortly afterwards.

Stage I (second phase) : since it is an essential part of the Gatwick proposal that the number of London's airports should be reduced from seven to three, the start of Stage I (second phase) is likely to follow close on the end of the first phase—say, in 1958. It should be possible for the decision on the construction of the subsidiary (N.E.-S.W.) runway to be taken in or before 1956.

Stage II : this stage of development is a reserve against the possibility that traffic might develop to the extent that the capacity of one main runway was exceeded. Traffic estimates up to 1965, which are bound to be somewhat speculative, suggest that this is unlikely to occur before that date, if ever.

Effects of the Revised Proposals

The line of the diversion of the London-Brighton road will be discussed with the local authorities concerned and the Crawley Development Corporation. However, the westerly movement of the runways now renders unnecessary any expensive westerly diversion of the road. It is now possible, without in any way prejudicing the construction of the Brighton radial road, to divert the road for the time being along the eastern boundary of the airport immediately to the west of the railway. New roads along this line will in any event be necessary to provide public access from the north and south to the airport and railway station.

The diversion of a short length of the Lowfield Heath-Tinsley Green road will, as in the original scheme, be necessary in the second phase, Stage I, of construction to make room for the maintenance area.

The diversions necessary under the revised proposals are : (i) only a diversion of the Charlwood-Lowfield Heath road will be necessary in Stage I of construction, and (ii) a diversion of a short length of the Povey Cross-Charlwood road would be necessary if Stage II of construction ever materialised.

Rather more land will be required for the construction of the aerodrome on the new layout. The total area of land to be taken in Stage I will be about 645 acres, against 520 under the former scheme, and for the full development about 1050 acres (assuming a subsidiary N.E.-S.W. runway), as against about 870 acres to which the existing aerodrome contribute in both cases nearly 400 acres. Rather more than half the land will remain available for grass drying and other agricultural purposes.

It is stated that the effect of building the southern runway first will be that aircraft taking off from and landing at Gatwick will not fly over any built-up areas in Stage I of construction. Only if the northern runway is required will aircraft fly close to Charlwood, and here the new alignment of the runway should help. The construction of the subsidiary runway along its new line will take aircraft using this runway away from the direct line over Horley and Crawley. Furthermore, the move of the new maintenance area northwards will reduce any possible disturbance to Crawley from that source. Unfortunately, the resiting of the southern runway unavoidably means that a number of houses which would previously have been close to, but sufficiently clear of, the runway will now have to be demolished.

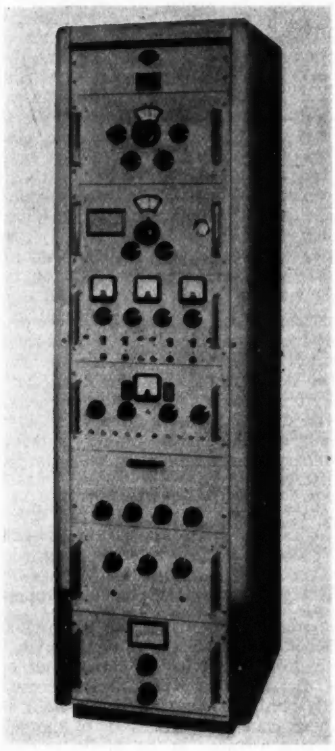
An Independent - Sideband Communications Receiver

We have received some details of an independent-sideband receiver which has been introduced by the Equipment Division of Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. In its circuit and chassis layout this equipment closely resembles the Mullard receiver "GFR 551," which was based on a British Post Office design (known as Radio Receiver No. 22).

It may be recalled that the technique of single-sideband (s.s.b.) operation has played an important part in the development of long distance point-to-point radio links. For single-sideband working has marked advantages over the more usual double-sideband (d.s.b.) method : the signal-to-noise ratio is notably improved, and there is increased freedom from non-linear distortion due to multi-path transmission. The new "GFR 551" independent-sideband receiver is designed for continuous use on long distance circuits passing telephone and telegraph traffic, and it provides for the simultaneous and independent reception of four telephone channels of 3 kc/s bandwidth, or two channels of broadcast quality of 6 kc/s bandwidth. Alternatively, each sideband can be used to accommodate several voice-frequency telegraph channels. It follows that the independent-sideband method of operation not only offers the same advantages as normal single-sideband operation, but has the added advantage of increased traffic

handling capacity. The receiver has a high order of oscillator stability and freedom from cross-modulation that might give rise to cross-talk between channels or inter-modulation between wanted and unwanted signals. When used for s.s.b. reception the receiver has two further advantages: first, it is free from the non-linear distortion that occurs in normal d.s.b. receivers when signals are subjected to selective fading conditions; secondly, either the upper or lower sideband can be selected for demodulation, depending upon which is the more free from adjacent channel interference.

The new receiver covers the band 4–30 Mc/s in three ranges: 4–10 Mc/s, 10–20 Mc/s and 20–30 Mc/s, and it is suitable for the following kinds of reception: first, "A3," that is, normal double sideband; secondly, "A3a," that is single sideband with pilot carrier, the carrier level being 16 db below the peak sideband power and, thirdly, "A3b," that is independent sideband with pilot carrier, the carrier level



Independent-Sideband Communications Receiver

being 26 db below the peak power of either sideband.

The receiver is of double superheterodyne design with intermediate frequencies of 3·1 Mc/s and 100 kc/s. The first oscillator can be used with crystal control, providing a choice of nine spot frequencies, or alternatively as a high stability variable oscillator, with good short-term stability and freedom from microphony. The second oscillator is self-excited and operates at a nominal frequency of 3·0 Mc/s. It has an automatic frequency control (a.f.c.), a motor-operated tuning capacitor covering a frequency range of ±4 kc/s, and the design is such that the control is operative even during deep fades. In addition a fine tuning control with slow motion drive is provided, covering an additional frequency range of ±4 kc/s. The a.f.c. system is designed to operate effectively with a pilot carrier level of −26 db relative to 1 microvolt (which corresponds to a peak sideband level of 1 microvolt and a signal-to-noise ratio of 15 db). The output from the second i.f. amplifier is applied, via hybrid transformers, to upper and lower sideband and carrier filters. The sideband filters employ X-cut crystals, so that variations of temperature affect the filters and the third oscillator equally and so no relative displacement occurs.

Each sideband amplifier is preceded by an attenuator, so that sideband levels of up to 4 db higher or 16 db lower than normal can be corrected to give normal level at the demodulator. Forward acting a.g.c. is applied to the second amplifier valve to compensate for the rise of sideband level of about 6 db that remains after the normal a.g.c. has operated on the r.f. units. Balanced diode demodulators, fed from a single hybrid transformer are employed in both channels, the a.f. output being almost independent of carrier level. The 100 kc/s local-carrier third oscillator uses a Pierce circuit with an X-cut crystal resonator. The frequency thus varies with the temperature in the same way as the mid-frequency of the carrier filter.

The manufacturer states that the noise factor of the set is better than 7 db over the band (4–30 Mc/s), the signal-to-noise ratio being 25 db for 4 microvolts peak sideband input over the band. The response is said to be flat within 2 db for sideband frequencies between 100 c/s and 6000 c/s. At 10 kc/s from the carrier frequency the response is given as 60 db relative to the pass band. It is stated that the third order intermodulation products which might result in cross-talk between sidebands do not exceed −50 db relative to the sideband levels. The output is variable up to +14 db relative to 1mW into 600 ohms.

As illustrated herewith, the equipment is mounted in a standard rack and cabinet, with doors at both sides and at the back. The overall dimensions of the complete equipment mounted in its cabinet are 7ft high, 24in wide and 26in deep. The power supply required is 200V to 250V, single phase, a.c., and the power consumption is 250VA.

A detailed treatment of the single and independent-sideband method of working will be found in the bibliography appended herewith.

BIBLIOGRAPHY

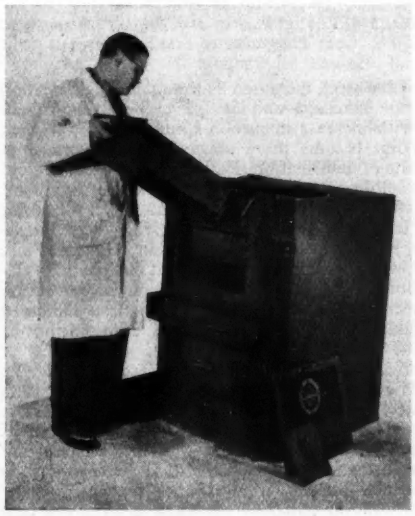
"Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio Links," Part 1, General Survey. N. J. Bray, M.Sc. (Eng.), A.M.I.E.E., and D. W. Morris, B.Sc., A.M.I.E.E. *The Post Office Electrical Engineers' Journal*, Vol. 45, Part 3, October, 1952.

"Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio Links," Part 2, "An Independent Sideband Transmitter Drive Unit and Monitor Receiver." F. C. Owen and A. B. Ewen. *The Post Office Electrical Engineers' Journal*, Vol. 45, Part 3, January, 1953.

"Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio Links," Part 3, "An Independent Sideband Short-Wave Radio Receiver." W. R. H. Lowry, B.Sc., and W. N. Genna. *The Post Office Electrical Engineers' Journal*, Vol. 46, Part 3, April, 1953.

A Small Barrel Finishing Machine

A SMALL precision barrel finishing machine is now being made by Roto-Finish, Ltd., 39, Park Street, London, W.1, for closely controlled deburring, descaling and polishing of small parts for the clock and watch-making, camera, radio and instrument industries. This machine, as can be seen in the illustration below, is a completely self-contained, compact unit. In it the separation of parts from the chip mass and the loading and unloading operations are all provided for by integral separating trays and loading pans. The machine is completely enclosed with a safety guard in front of the rotating barrel.



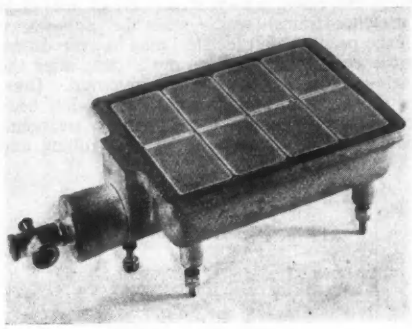
Barrel Finishing Machine for Small Parts

The barrel can be provided in two sizes—either 16in long and 16in across the flats, divided into two separate compartments if required. For particularly small parts or batch quantities a smaller barrel only 12in across the flats can be supplied. In sliding trays under the barrel a set of interchangeable screens are fitted, to permit separation between different sizes of parts and the "Rotofinish" grinding or "Britehoning Chips" used with the machine. Normal separation procedure allows the chips to flow through the screens into a self-contained hoist-pan fitted in the slides under the trays. The hoist-pan itself is fitted with grips so that when full of chips it can be lifted by hand and fitted into the barrel opening for the chips to slide into the barrel ready for the next process. To ensure cleanliness of operation the machine is made self-draining, all solutions being sluiced out through a hole at one side.

A Flameless Radiant Gas Burner

AT a demonstration at the Building Centre in London last week Radiant Heating, Ltd., of Barnsbury Park, London, N.1, introduced the "Mastertherm" flameless combustion burner for gaseous fuels which it is now manufacturing and showed a number of applications for the burner. The burner, unlike the other flameless combustion appliances made by the firm, does not need a supply of air under pressure to operate. All of the air required for combustion in this unit is drawn in at the throat of a venturi tube and no secondary air is required.

The arrangement of the burner can be seen in the illustrations on this page. It consists essentially of a well finished cast iron container into the top of which are fitted perforated plaques of a special high refractory material. In the lower part of the container is a venturi injector



Flameless Gas Burner

designed to operate effectively on low pressure gas at 1·6in water gauge, which is supplied through an injector nipple from the gas main. This working gas pressure is available throughout this and most other countries and a range of calibrated injector nipples is available to conform with the different calorific values and densities of the gases in various areas. A small sensitive governor is fitted to maintain the gas pressure uniform in the unit.

When the burner is first lighted the gas burns off the surface of the plaques for a few seconds and then recedes sufficiently to bring the plaques up to a temperature of 850 deg. Cent., which is thereafter maintained. Lighting back is prevented by the high insulating properties of the material used in the plaques.

Standard burners are made with a radiant surface 7½in long by 5½in wide, and other sizes can be made to suit special requirements. These standard burners have an input of 10,000 B.Th.U.s per hour.

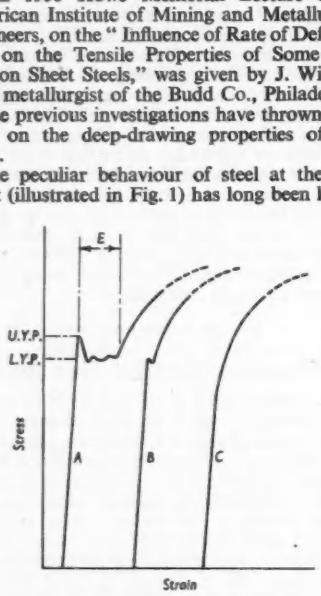
The burners can be used singly or in groups in a wide variety of forms for industrial and other heating purposes. At the demonstration they were shown arranged for drying tunnels, radiant heating units, &c.

Metallurgical Topics

Rapid Deformation of Sheet Steel

THE 1953 Howe Memorial Lecture of the American Institute of Mining and Metallurgical Engineers, on the "Influence of Rate of Deformation on the Tensile Properties of Some Plain Carbon Sheet Steels," was given by J. Winlock, chief metallurgist of the Budd Co., Philadelphia, whose previous investigations have thrown much light on the deep-drawing properties of steel sheet.

The peculiar behaviour of steel at the yield point (illustrated in Fig. 1) has long been known



A, annealed or normalised, showing upper yield point (*U YP*), lower yield point (*L YP*), and yield-point elongation (*E*).

Fig. 1—Stress-Strain Curves of Low-Carbon Steel in Different Conditions (Jevons)

and has been the subject of much research.[1] It is of practical importance for at least two reasons. The highly localised plastic flow at the yield point gives rise to surface markings (stretcher-strains) which mar the appearance of the product, and the steel may be deep drawn more easily and, to a greater extent, after the yield-point elongation has been removed. Thus, in the deep drawing of mild steel it has been customary to apply a preliminary treatment comprising a combination of cold rolling and

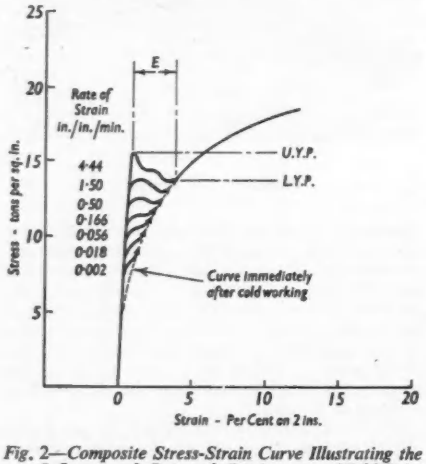
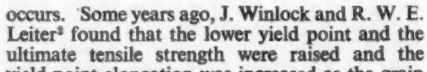


Fig. 2—Composite Stress-Strain Curve Illustrating the Influence of Rate of Strain upon Yield-Point Elongation of Annealed Low-Carbon Steel (Winlock and Leiter)

roller levelling designed to put the steel into the condition represented by Curve *C* in Fig. 1. If the yield-point elongation is not thus eliminated and the rate of deformation is too rapid, the steel may fracture when plastic deformation first occurs, that is, at the first stretcher-strain. The rate at which straining is carried out has a most important influence on the magnitude of the yield-point elongation, and hence upon the severity of the stretcher-strain markings formed, and also on the stress at which the yield point occurs. Some years ago, J. Winlock and R. W. E. Leiter[2] found that the lower yield point and the ultimate tensile strength were raised and the yield-point elongation was increased as the grain size was made smaller and as the rate of deformation increased up to 4·44in per inch per minute (Fig. 2). This is below the speed of most drawing operations, which would normally be ten times as fast as this. A special high-speed testing



In Figs. 3 to 6 the curves from the lowest to the highest, in order, represent rates of deformation in inch per inch per minute of 0·002 (lowest), 0·018, 0·166, 1·50, 20 and 200 (highest curve).

Figs. 3 and 4—Effect of Rate of Deformation on the Upper and Lower Yield Point of Steels (Winlock)

apparatus was therefore designed, allowing of speeds up to 450in per inch per minute and loads up to 3000 lb.[3] Five steels were used in the form of normalised sheet, 0·035in thick. The carbon contents of the five steels were 0·06, 0·21, 0·34, 0·48 and 1·03 per cent, other elements being as nearly as possible the same in each steel. The steels were deformed at six different rates, 0·002in, 0·018in, 0·166in, 1·50in, 20in and 200in per inch per minute. For any given steel the upper yield point increased with increased rate of deformation; the increase was independent of carbon content up to 0·48 per cent (Fig. 3). The lower yield point, which gives a more reliable indication of the elastic behaviour

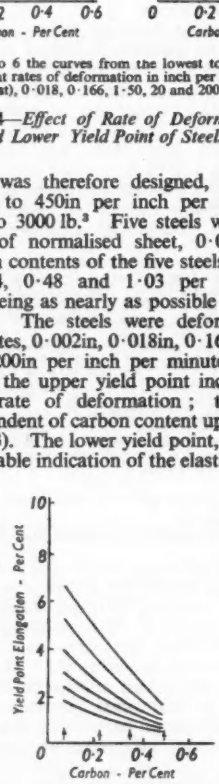


Fig. 5—Effect of Rate of Deformation on the Yield-Point Elongation of Steels (Winlock)

of the steel, increased as the rate of deformation was increased and as the carbon was raised. With increase in carbon content the lower yield point became more affected by an increase in rate of deformation (Fig. 4). The hypereutectoid steel deformed in much the same way as a cold-worked, low-carbon steel; no upper or lower yield point was shown. In this steel in the spheroidised condition, however, an upper and lower yield point occurred at all rates of deformation. The amount of yield-point elongation increased as the rate of deformation increased and decreased as the carbon was raised, but as the carbon increased it became less affected by an increase in the rate of deformation (Fig. 5). The total elongation of the 0·06 per cent carbon steel rose from 31·5 to 39 per cent on 2in as the rate of deformation was increased, but both its actual value and its rise with increased rate of deformation diminished with increase in carbon content, until with 0·48 per cent carbon the elongation remained constant at 17·5 per cent for all rates of deformation. It also remained unchanged at 13·5 per cent in the 1·03 per cent carbon steel. The ultimate tensile strength naturally increased with carbon content, but it also increased with rate of deformation, by which it was influenced to a greater extent in the higher than in the lower carbon steels (Fig. 6). From the convergence of the curves at low carbon, it would appear that the ultimate tensile strength of pure iron would be little affected by high rates of deformation.

The work described further illustrates the effects to be expected from the progressively

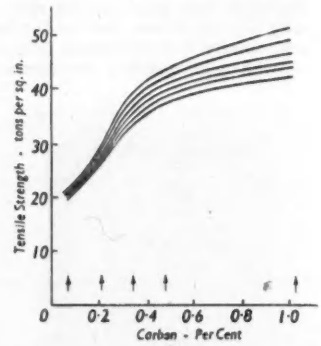


Fig. 6—Effect of Rate of Deformation on the Ultimate Tensile Strength of Steels (Winlock)

higher rates of pressing imposed by the demands of production engineers. The load-sustaining properties of the steel are enhanced by increased rate of deformation, but the increased yield-point elongation of the annealed or normalised material directs attention to a difficulty which can only be overcome by careful control of the preliminary temper rolling and roller levelling.

REFERENCES

[1] J. D. Jevons: "The Metallurgy of Deep Drawing an Pressing," pages 228–237.
[2] *Trans. Amer. Soc. Metals*, 1937, Vol. 25, page 163.
[3] *Journal of Metals*, June, 1953, page 797.

Effect of Pressure on Tensile Properties

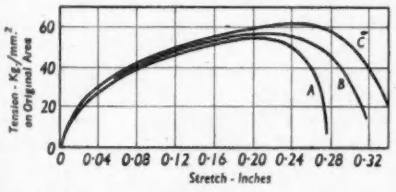
THE results of many of the well-known researches on the behaviour of materials under high hydrostatic pressures, carried out by Dr. P. W. Bridgman, of Harvard University, have recently been collected together in book form.* The book includes an account of the effect of hydrostatic pressure on the tensile properties of steel. The most striking phenomenon is the very great increase in ductility brought about by testing under pressures up to about 30,000 kg per square centimetre. Under high pressure the reduction of area is so great that it is no longer measurable, the tensile specimen being drawn out almost to a point before fracture. Steel also exhibits two other independent effects: strain hardening, which increases linearly with pressure, indicating (by extrapolation) the possibility of indefinitely high tensile strength under a sufficiently high pressure; and a linear dependence of the strain at fracture on the supporting pressure.

Dr. Bridgman† has now carried out tension tests to fracture under superposed hydraulic pressures reaching nearly 30,000 kg per square centimetre on five polycrystalline metals (nickel, tantalum, niobium, molybdenum and tungsten), on two brittle single metallic crystals (antimony and gamma-brass, Cu_5Zn_8), and on two brittle amorphous substances (a plastic, Melmac 404, and boric anhydride glass). In addition to tensile tests at atmospheric pressure, two types of measurement were made:—(1) Determination of the effect of pressure on ductility. This involved pulling the specimen to fracture under several pressures, spaced over a range, and plotting reduction of area at fracture as a function of the pressure. Several of the metals draw down to an immeasurably small section at pressures

* P. W. Bridgman: *Studies in Large Plastic Flow and Fracture*, McGraw-Hill Book Company, New York, 1952
† *Journal Appl. Physics*, May, 1953, page 560.

much below 30,000kg per square centimetre. (2) Determination of the strain hardening curve. This involves pulling to a predetermined reduction of area at an assigned pressure ; removal from the pressure apparatus ; measurement of the reduction of area ; replacement in the pressure apparatus and further pulling at the same pressure. This was repeated several times and yielded a curve of reduction of area against the corresponding tension for a particular fixed pressure. The entire procedure was then repeated with other specimens at other fixed pressures, yielding finally a set of strain hardening curves as a function of the pressure applied to the specimen. The equipment and experimental procedure are the same as for steel as described in the book mentioned above.

All the polycrystalline metals showed a large increase in ductility at high pressures, the greatest increase being shown by tungsten, which broke at 71 tons per square inch in a brittle manner at atmospheric pressure but with a reduction of area of 81 per cent at 81·5 tons per square inch under the highest pressure applied. Nickel, of 99·4 per cent purity and tensile strength 34·4 tons per square inch, already very ductile at atmospheric pressure, had its reduction of area increased from 82 per cent to 92·5 per cent by a pressure of 7700 kg per square centimetre ; and at higher pressures the maximum load rose to 39·4 tons per square inch and the cross sectional area was too small to measure. The strain hardening of nickel is a slow process, and the maximum of the stress-strain curve, which marks the beginning of necking, is unusually long deferred. The maximum load is higher and it is displaced to a greater elongation the higher the applied pressure. The curves for nickel are shown in Fig. 1. Tungsten, on the other hand, shows a much more abrupt rise to a maximum and more gradual falling off (Fig. 2). The other metals showed intermediate behaviour in the order tungsten, molybdenum, tantalum, niobium, nickel. The maximum loads were increased by an amount roughly the same as for steel, i.e. 5 per cent per 10,000 kg per square centimetre pressure. Strain hardening at first increases markedly with pressure, but does not always continue to increase indefinitely, as does that of steel. The curve may turn over with eventual softening rather than hardening. A tendency in this direction is shown by nickel, but Dr. Bridgman is of the opinion that this behaviour is the result of actual material damage to the specimen at very high strains. As is evident in Fig. 2, tungsten exhibits the phenomenon of a

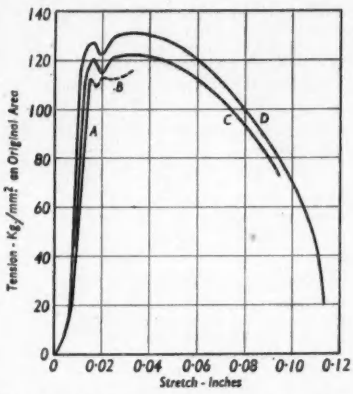


Curve A—Pulled at atmospheric pressure ; Curve B—At 8000 kg. per square centimetre ; Curve C—At 26,000 kg per square centimetre

Fig. 1—Load-Extension Diagram of Nickel Tested Under Hydrostatic Pressure (Bridgman)

second yield point under pressure, the effect being more marked at the higher pressures. Molybdenum shows the effect in less degree. Several grades of steel also showed it, but with diminishing prominence under pressure. All the metals exhibited progressive changes in the character of the fracture as the hydrostatic pressure was increased. The original cup and cone fracture gave place to a fracture which occurred in jagged prongs or in a star-shaped arrangement of knife edges. The surface of the molybdenum specimen was strongly ribbed or marked with deep undulations. At the same time the texture of the fractures became finer.

The main part of the paper dealt with the five polycrystalline metals, but interesting observations were made on the other materials. The experiment with gamma-brass had to be discontinued, but not before a reduction of area of 10 per cent had been registered. This occurred under a superposed pressure of 27,000 kg per square centimetre with no necking ; there was a gradual increase in tensile stress up to fracture. Brittle single crystals of antimony showed a reduction of area of 55 per cent when tested in tension under pressure. The tensile load on the specimen quickly rose to a maximum and then fell off as necking occurred. The final fracture was a smooth mirror-like plane. The plastic investigated (Melmac 404) gave a smaller increase in ductility under pressure. The maximum reduction of area was only 14 per cent, a result which Dr. Bridgman considered to be associated with the absence of internal slip planes. Boric anhydride glass, on the other hand, although an amorphous substance, showed a reduction of



Curve A—Pulled at atmospheric pressure ; Curve B—At 7000 kg per square centimetre ; Curve C—At 13,500 kg to 16,000 kg per square centimetre ; Curve D—At 23,000 kg to 27,800 kg per square centimetre

Fig. 2—Load-Extension Diagram of Tungsten Tested Under Hydrostatic Pressure (Bridgman)

area of 87 per cent. This was probably due to the capacity of the glass for viscous flow. It is of interest to note that both these amorphous materials showed an increase in density after being pulled under pressure, instead of a decrease as shown by the metals.

Dr. Bridgman has previously suggested that a crystalline substance is more likely to give increased ductility under high hydrostatic pressure than an amorphous substance. This is borne out by the results now reported ; but, among amorphous substances, it would seem that an exception must be made of some glasses and similar substances which exhibit a viscous behaviour.

Creep-Resisting Magnesium Alloy

THE advent of the jet engine created a demand for a light sand-casting alloy capable of being cast in large complex shapes and of resisting creep at temperatures up to 260 deg. Cent. This demand has in the past been largely met by alloys of the magnesium-cerium-zirconium type containing about 3 per cent of cerium (mischmetal) and 0·7 per cent of zirconium, typified by Elektron magnesium alloys MCZ and ZRE1, the latter alloy also containing 2·5 per cent of zinc. With increasing power of modern jet engines the temperatures to which some of the magnesium parts are subjected are likely to exceed the safe working range of the mischmetal containing alloys. About four years ago attention was directed by F. Sauerwald to the beneficial effect of thorium, and since then the thorium-containing alloys of magnesium have been investigated and developed by T. E. Leontis and others in America. Leontis arrived at the conclusion that magnesium-3 per cent thorium-zirconium (without specifying the exact zirconium content) represented the optimum composition. At the same time the investigation of these alloys was being undertaken by the Magnesium Elektron Company, who have published results leading to further developments.* The properties of the alloy containing 3 per cent thorium and 0·7 per cent zirconium are given in detail. Its creep resistance was better than that of the alloy containing cerium (mischmetal) zirconium and zinc, but the addition of zinc to the magnesium-thorium-zirconium alloy produced a pronounced improvement. The thorium/zinc ratio giving the greatest improvement in creep resistance was about 1·3 corresponding, to thorium 3 per cent, zinc 2·5 per cent. This alloy, with about 0·7 per cent zirconium, is known as ZT1.

The very marked effect of zinc in improving the creep resistance of the magnesium-thorium-zirconium alloy is illustrated in Fig. 1, which shows the effect of 2·5 per cent of zinc on the

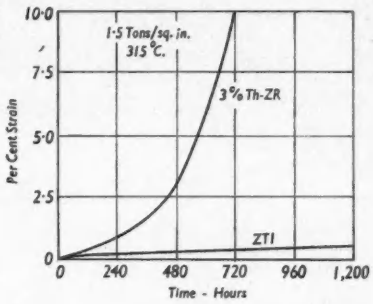


Fig. 1—Creep Tests on 3 Per Cent Thorium-Zirconium-Magnesium and the Same Alloy with 2·5 Per Cent Zinc (Ball and Others). Stress 1·5 tons per square inch, temperature 315 deg. Cent.

thorium 3 per cent, zirconium 0·7 per cent alloy when tested for creep at a stress of 1·5 tons per square inch at 315 deg. Cent. The zinc-free alloy in the solution treated condition developed rapid tertiary creep after 300 hours, leading to ultimate fracture before the end of 1000 hours, whereas the ZT1 alloy extended about 0·4 per cent in 1000 hours. Thorium cannot be replaced, even in part, by cerium (mischmetal) without sacrifice of resistance to creep. The creep resistance of ZT1 offers a permissible increase of 65 deg. Cent. in service temperature over the ZRE1 alloy, the corresponding cerium (mischmetal) composition. Whereas ZRE1 alloy is satisfactory at a stress of 0·5 ton per square inch at 250 deg. Cent., it shows considerable deformation at 315 deg. Cent. This is shown in Fig. 2. On the

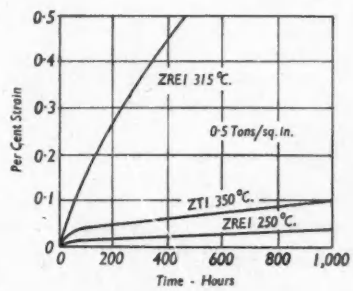


Fig. 2—Comparison of Alloys ZAE1 and ZT1 in Creep Under a Stress of 0·5 Ton Per Square Inch (Ball and Others)

other hand, ZT1 is seen to display satisfactory creep resistance to the same stress at 350 deg. Cent. An indication of the mechanical properties of the alloy, which are reported in some detail, is given in the following table, which refers to cast ZT1 stabilised for eighteen hours at 315 deg. Cent :—

Temperature of test, deg. Cent.	20	...	325	...	350
0·2 per cent proof stress, tons per square inch	6	...	3·2	...	3·1
Ultimate tensile strength, tons per square inch	13	...	4·5	...	4·3
Elongation per cent on 2in ...	5 to 10	...	40	...	35
Fatigue strength, 10^8 reversals, tons per square inch	4·5†	...	1·5	...	1·05

† 5×10^7 reversals

The alloy has been successfully cast in sand. Castings up to 200 lb in weight were free from microporosity and large thin-walled castings were pressure tight. It has adequate ductility to safeguard it against thermal shock and it is readily weldable by techniques now in use for magnesium alloys. It is claimed to exhibit, in an adequate degree, all the factors essential for its use as a high-temperature material.

* C. J. P. Ball, A. C. Jessup, P. A. Fisher, D. J. Whitehead and J. B. Wilson, *Journal of Metals*, July, 1953, page 924.

THE ENGINEER

Vol. 196 JULY 31, 1953 No. 5088

LEADING ARTICLES—
Science and Productivity 144
New Weapons 144

ARTICLES—
Airframe Test House and Wind Tunnel. (Illus.) 147
Airline Traffic Statistics for 1952–53 129
Chemical Research in 1952... 129
Commonwealth Bursaries Scheme 129
Cornish Engine Preservation Society 145
Double-Head Vertical Grinding Machine. (Illus.) 156
Electronics Exhibition in Manchester 145
European Organisation for Nuclear Research... 151
Flameless Radiant Gas Burner. (Illus.) 141
Forms of Sections for Struts. (Illus.) 133
Gatwick Airport Development. (Illus.) 140
" Gyron " Turbo-Jet Engine 139
Heart and Lung Machine. (Illus.) 150
Independent-Sideband Communications Receiver. (Illus.) 140
Industrial Applications of Radioactive Materials. (Illus.) 153
" King Edward " Turbines... 129
Materials Handling Report 156
Medium-Power X-Ray Generator. (Illus.) ... 156
Mobile Crane Works in Sunderland. (Illus.)... 148
Naval Architects Autumn Meeting 145
Paint Coating Thickness Meters. No. I. (Illus.) 130
Pedestrian Controlled Fork Lift Truck. (Illus.) 152
Performance and Efficiency Tests on the " Britannia " Locomotive. No. II. (Illus.) 136
Portable Grain Handling Equipment. (Illus.) 155
Royal Aeronautical Society 129
Small Barrel Finishing Machine. (Illus.) ... 141
Welded Light Alloy Yacht. (Illus.)... 138
110in Gear Hobbing Machine. (Illus.) 152

METALLURGICAL TOPICS—
Rapid Deformation of Sheet Steel. (Illus.) ... 142
Effect of Pressure on Tensile Properties 142
Creep-Resisting Magnesium Alloy 143

LITERATURE—
Books Received 145
Short Notices 145

NEWS AND NOTES—
British Patent Specifications. (Illus.) 159
Contracts 160
Forthcoming Engagements... 160
Industrial and Labour Notes 157
Launches and Trial Trips 160
Notes and Memoranda 158
Personal and Business 158
Technical Reports 160

SCIENCE AND PRODUCTIVITY

Last week, the House of Commons devoted six and a half hours to a debate on science and productivity. During that debate there were inevitably many things said that have been said time and again, in and out of Parliament, in the post-war years. At no point in the debate did there emerge any acrimonious division of opinion about the necessity for British industry to derive the fullest possible benefit from scientific progress. The text for the debate was provided by the appearance a fortnight or so ago of the annual report of the Advisory Council on Scientific Policy, extracts from which were printed in our issue of July 17th. That report put it plainly that " for our economic survival in an increasingly competitive world, our industry must put more emphasis on new methods and new products which depend on engineering and scientific skills." Mr. R. R. Stokes, the Labour Member for Ipswich, who opened last week's debate, began with a reference to the report and pointed to " the need for capital investment if we are to take full advantage of all the various scientific developments which there have been both in this country and elsewhere." He spoke in particular from his knowledge and experience in the engineering industry, referring in turn to a number of matters including joint consultation, incentives, and fuel economy. Mr. Stokes also made it clear that he wanted to see " a far greater mechanisation of the manual effort in the workshop, making the job lighter and saving fatigue." That, he emphasised, " was not pandering to the inordinate desire of man to get the maximum result with the least effort." It revealed, rather, an attempt to make a tremendous contribution to increased production.

Achieving the maximum result from our industrial effort was, indeed, the main theme throughout the debate. The Minister of Labour, Sir Walter Monckton, summed it up neatly as " getting more than we have been getting out of the same resources." He spoke of the reluctance of some employers to introduce new and more efficient processes because they feared the resistance which reorganisation might arouse among those who worked in their undertakings ; but he urged that industry should not hesitate to introduce changes so long as it was satisfied that such changes were wise and necessary to greater efficiency. That is sound advice, even if, in the face of opposition from shop stewards and men and often union officials, it is not easy to take it. It is advice with which very few, if any, engineers would disagree. For they are well aware that, with increasing competition in the world's markets, greater efficiency in production is essential to greater economy in manufacturing processes. Research, whether it be the research of individual firms or research organised on a co-operative basis, would be useless to engineers did it not point the way, when its results were applied, to greater efficiency and economy. The engineering industry like every other industry, is now operating under circumstances which demand high quality products at the right price. The politicians who participated in last week's debate undoubtedly appreciate that fact ; those who are responsible for the running of this country's businesses, both large and small, appreciate it even more fully. But we wish we could feel more assured than we do that the workpeople throughout industry were equally aware that highly efficient and economic production is not only imperative to our industrial and national survival, but highly beneficial to themselves and something to be strained after rather than regarded askance. Unfortunately, there still lurks the fear that the first thing to be expected from new methods and enhanced productivity must be higher unemployment. Certainly, as the Minister of Labour said, it becomes difficult to introduce changes in working methods unless human relations are good and there is readiness on the part of all concerned to entertain such changes.

A couple of days after the debate, the Chancellor of the Exchequer spoke to the Minister of Labour's National Joint Advisory Council, on which employers' organisations, the trade unions and the nationalised industries are represented. He said that the present general level of our export prices was 3 per cent below last year's average, a state which had been reached not by reducing costs of production in the factory, but by the fall in the prices of raw materials which, it must be remembered, favoured our competitors as well as ourselves. Clearly, the Chancellor added, we could not meet competition if we had to grapple with rising costs of production in the factory. To-day, industry cannot stand still. It must be quick to seize every opportunity for advancement which may be indicated by scientific progress. There is still plenty of scope for skill and technical ability, and there is still a great place for turning out the best possible job in the best possible way. If British industry —and especially the British engineering industry—is to flourish, all these qualities are highly desirable in those who are engaged in it. Given the opportunity, applied science and sound human relations together can undoubtedly do much towards making industry's " rough places plain."

NEW WEAPONS

It is becoming clear that the application of atomic explosives to conventional weapons will revolutionise the manner in which the soldier—and, indeed, any unit of any armed force—is employed in battle. The mere threat of an atomic missile will inevitably necessitate dispersion of both attacking and defending forces. It will in fact be the aim of each side not to disperse his opponent's forces so that superior force may be brought to attack at the decisive point but, on the contrary, to compel his enemy to concentrate and thus to present a worthwhile target for atomic missiles. It is perhaps too early yet to foresee the ultimate effects which atomic weapons will have on land and sea warfare, but there can be little doubt that great concentrations of troops and material, as in the invasion of Normandy, will be out of the question. They would simply invite atomic attack.

In a recent issue of this journal reference was made to the prototype 280mm gun, firing an atomic shell, which has been developed for the United States Army. This new weapon will give the ground commander tremendous fire power under his immediate control—immeasurably greater fire power than any artillery hitherto known—and will be capable of use in all kinds of weather. According to United States official accounts, it is carried on a platform suspended between two tractors at front and rear, and can travel at a speed of about 35 miles an hour on a highway. Weighing about 75 tons, it is not too heavy to cross the normal bridge which Army engineers are trained to build for heavy divisional equipment. It is also capable of travel across country and will fit into a landing ship designed for amphibious operations. Its accuracy of fire is comparable with that of conventional artillery—indeed, at long ranges it is more accurate than the conventional gun. In short, the

atomic gun will give ground troops the kind of devastating support never before available in warfare and there is every reason to believe that it will prove equally effective when adapted for sea warfare. Courses in atomic warfare have now been started in United States Army schools ; and selected Army officers and civilian specialists are sent to a Joint Service School in New Mexico, where they study the characteristics and uses of atomic weapons. Every endeavour is in fact being made to keep the United States Army informed of atomic developments and to accustom soldiers to include atomic weapons in their tactical thinking. The British Army is also being kept up to date and officers studying at Camberley Staff College are to carry out an "atomic warfare" exercise during the summer of this year.

Atomic shells—and atomic warheads for the guided rocket, torpedo and mine which will follow—are the direct result of the development of bombs much lighter and less cumbersome than those dropped at Hiroshima and Nagasaki, which required a very large aircraft to carry them. At the present day the United States has several different kinds of bomb casings and the atom bomb with its detonating mechanism is now small enough to be carried in carrier-based aircraft. An even smaller one is envisaged to be carried on external bomb racks by jet fighter-bombers. Meanwhile, the piloted bomber is already finding it difficult to penetrate well organised anti-aircraft defences of radar warnings and interceptor fighters and may well find it impossible "at an early date when"—as recently announced by the United States Secretary of Defence—"the Army is provided with a guided missile capable of rapidly and accurately engaging and destroying the most modern high performance bombers at altitudes and ranges hitherto unknown." Fortunately, the United States has the wealth and resources to provide for both immediate needs and the probabilities of the near future. While still constructing adequate numbers of heavy bombers, in addition to medium bombers and giant aircraft carriers to carry them, missiles—guided rockets—are being developed to carry atomic warheads well beyond the range of existing artillery weapons. The "Matador B-61" pilotless tactical bomber is now in production and the first pilotless bomber squadron has been equipped with this missile—the first operational unit of its kind.

The Cornish Engines Preservation Society

FINAL arrangements are now in hand for a ceremony of great interest to the engineering world, which will take place at the Camborne Engineering Museum on Saturday, September 12, 1953, when Lord Falmouth, who is the president of the Cornish Engines Preservation Society, will formally present to that Society the 22in Rostowrack rotary Cornish engine which was formerly used for combined pumping and winding in one of Lord Falmouth's china clay pits. The engine has been removed and re-erected in the museum opposite Richard Trevithick's statue in Camborne. This engine was built in Cornwall in 1851, and continued in service to about 1951 ; it has now been overhauled and erected in keeping with normal early nineteenth century Cornish mine engineering practice. The above ceremony will be preceded by another interesting event at 2.30 p.m., when Captain R. E. Trevithick, M.I.C.E., a great grandson of the famous Cornish engineer, Richard Trevithick, will unveil a commemorative plaque on the "Richard Trevithick Cottage" at Penponds, the home of the pioneer of high-pressure steam and the "Father of the Locomotive." The Cornish Engines Preservation Society has made commendable progress in its aim for the formation of a "National Trevithick Site Museum." The Society now possesses other properties, including a magnificent 90in Cornish pumping engine still at work on East Pool mine ; a 30in rotative Cornish beam winding engine on the same mine, and a 24in beam winder at the famous Levant mine, built and erected in 1840. The Society hopes in the future to be associated in the preservation of a still more famous engine, the 80in Cornish pumping engine at Robinson's Shaft, South Crofty tin mine ; this engine was built at Hayle in 1854, and it is still at work, and within a year will have completed a century of useful activity.

Naval Architects' Autumn Meeting

AT the invitation of Koninklijk Instituut van Ingeneiurs, the Institution of Naval Architects is holding its autumn meeting in Holland. It will take place at the Kurhaus, Scheveningen, and will open on Monday, September 14th. Three papers will be read on Tuesday, September 15th, one in the morning entitled "Present-Day Development of Ship Model Research in Netherlands Ship Model Basin at Wageningen," by Professor dr. ir. W. P. A. van Lammeren, and two in the afternoon, namely, "Tests of Launching Greases," by J. Brown, B.Sc., and J. M. Ferguson, and "Optical Marking Off System for Plates and Sections in Shipbuilding," by Ir. J. H. Krietemeijer.

The meeting will be continued on Wednesday, September 16th, with the reading of three papers, two in the forenoon with the following titles "On Propeller Manufacture," by Professor L. C. Burrill, M.Sc., Ph.D., and "The Hydromechanics Research Programme of the Bureau of Ships, U.S. Navy," by Dr. F. H. Todd, B.Sc., Ph.D., and in the afternoon "Investigations of Ships' Hull and Machinery Defects," by T. W. Bunyan, B.Sc.

During the meeting there will be official receptions, concerts, visits and excursions of topical interest.

Electronics Exhibition in Manchester

THE eighth annual exhibition of electronic apparatus and equipment, which was organised by the North-West Branch of the Institution of Electronics was held at the College of Technology, Manchester, from July 15th to 21st. More than 12,000 people visited the exhibition, in which there were forty-five stands showing examples of the products of leading manufacturers of electronic equipment. In addition to the exhibition stands there was a full programme of fifty-five lectures by specialists in various branches of electronics and a continuous demonstration of research exhibits, television and scientific films. At this year's exhibition the emphasis was on the application of electronics to medical research and treatment. An exhibit of particular interest was a prototype equipment which may be described as an "extra-corporeal heart and lung." This equipment, which was developed by the Postgraduate Medical School of the University of London, is described on page 150 of this issue. Briefly, it is designed to take over the function of a human heart in pumping blood through the system of a patient, and of the lungs in oxygenating the venous blood. This result is achieved by pumping the blood from the patient through a rotating plastic cylinder designed to present the maximum surface area of blood to the action of oxygen. Another exhibit provided an example of the application of television technique to medical research. It showed how radioactive materials administered to patients can be scanned on a television screen to show the distribution of the materials in the body. For this purpose use was made of a "storage tube," in which an image recorded on the sensitive surface is picked off by a separate high-speed scanning system. Visitors to the exhibition were also able to see an eight channel electro-encephalograph for recording brain activity as a waveform. Outside the medical field there was a demonstration of an experimental colour television system using three 14in tubes with dichroic mirrors and coloured phosphors.

Short Notice

Forging and Forming Metals. By S. E. Rusinoff. Surrey : The Technical Press, Ltd., Gloucester Road, Kingston Hill. Price 32s.—According to the preface, this book is dedicated to the end that a fuller understanding of forging and forming processes may be had by basic employees, shop foremen, plant supervisors, technicians, engineers, and executives in the metal working industry. In accordance with this object it attempts to cover a wide field and is written in a very elementary manner. Those who are intimately connected with any particular forging process will not, therefore, expect to learn anything new from the section devoted to their own field of work and the serious student will have to look elsewhere for a full and deep understanding of the technicalities of metal working processes. On the other hand, those who are unfamiliar with modern methods of shaping metals will find the book easy to read and will certainly get a clear impression of the tools, equipment and techniques involved. The book covers the following subjects : steelmaking and ingot quality, hand forging, impact forging, press forging, upsetting, extrusion, heat treatment, cleaning, finishing and inspection of forgings, safety in the forge and the design of forged parts, dies and tools. The "review questions" at the end of each chapter are of little value and require no original thought. They all simply call for descriptions of equipment and methods given in preceding pages.

Books Received

Public Health Engineering. By Peter C. G. Isaac. London : E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, W.C.2. Price 36s.

Mechanics of Materials. By Seibert Fairman and Chester S. Cutshall. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 46s.

Industrial Frustration. By Lewis C. Ord. London : The Mayflower Publishing Company, Ltd., 17, Farringdon Street, E.C.4. Price 12s. 6d.

Water Engineers' Handbook, 1953. London : The Colliery Guardian Company, Ltd., 30 and 31, Furnival Street, Holborn, E.C.4. Price 18s.

Handbook on Track Laying for Underground Haulage. London : National Coal Board, Hobart House, Grosvenor Place, S.W.1. Price 5s. 6d.

Motion and Time Study Applications. Second edition. By Ralph M. Barnes. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 24s.

Welding Technology. Second edition. By F. Koenigsberger. London : Cleaver-Hume Press, Ltd., 42A, South Audley Street, W.1. Price 25s.

The Earnings of Industry. 1953 edition. London : Aims of Industry, Ltd., Editorial Department, 12, Carteret Street, Westminster, S.W.1. Price 4s.

Les Diagrammes Enthalpie-Entropie, Applications à l'Air et aux Gaz de Combustion. By P. Chambadal. Paris, 6e : Dunod, 92, Rue Bonaparte. Price 940f.

High-Temperature Alloys. By Claude L. Clark. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 60s.

Technology of Engineering Materials. By B. Richard Hilton. London : Butterworth's Scientific Publications, Bell Yard, Temple Bar, W.C.2. Price 36s.

Kinematics of Mechanisms. By N. Rosenauer. Australia : Associated General Publications Pty., Ltd., 26, Hunter Street, Sydney, N.S.W. Price £ (Aust.) 4 10s.

Materials Handling. By John R. Immer. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 57s. 6d.

Accidents, How They Happen and How to Prevent Them. London : Published for the Factory Department, Ministry of Labour and National Service, by Her Majesty's Stationery Office, Kingsway, W.C.2. Price 1s.

AIRFRAME TEST RIG AND WIND TUNNEL AT RADLETT AERODROME

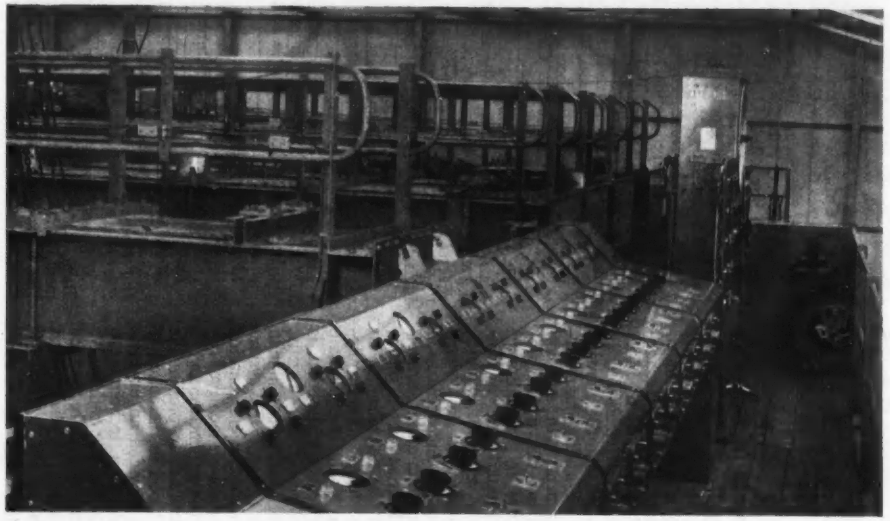


Fig. 1—Test Rig Operating Desk and Dynamometer

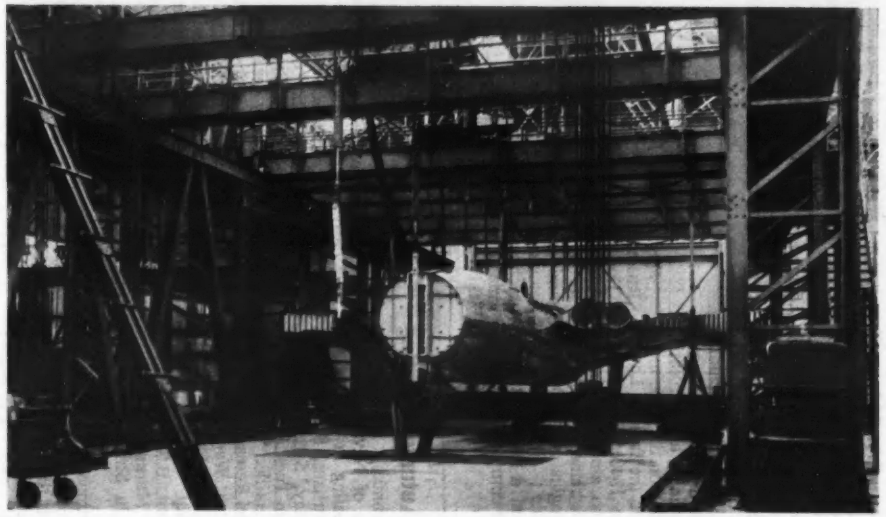


Fig. 2—Structural Test Rig

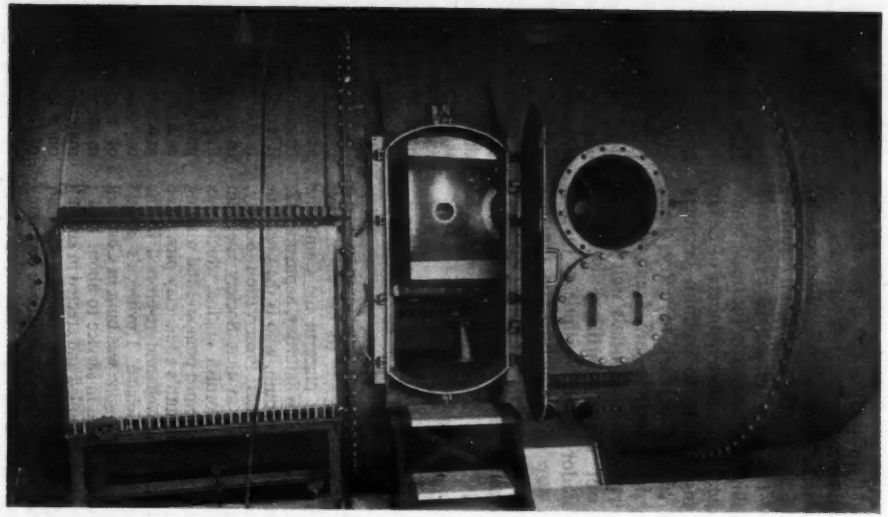


Fig. 3—Pressure Cell Showing Window and Entrance to Working Section of Tunnel

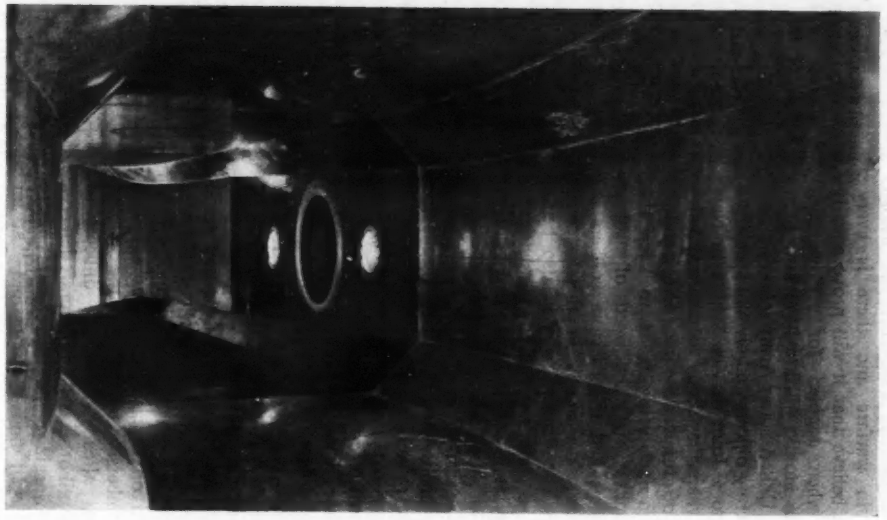


Fig. 4—Working Section of Tunnel Viewed from Nozzle

Airframe Test House and Wind Tunnel

Both in this country and the United States of America it has become essential for the principal aircraft manufacturing firms to provide testing and research facilities for high-speed aircraft of an order hitherto installed only at Government research establishments. In this way it is hoped to expedite considerably the design and development stages, to shorten the flight development time and reduce the likelihood of modifications to prototype and early production aircraft. The equipment now available at the Radlett aerodrome of Handley Page, Ltd., makes the company largely independent of outside assistance in design, construction and proving.

A NOTABLE item of the research equipment formally opened last week at the Radlett aerodrome of Handley Page, Ltd., by the Parliamentary Secretary to the Ministry of Supply, Mr. Low, is the 4ft by 3ft high-speed wind tunnel. The tunnel can operate at high subsonic velocities and, with a clear working section, the speed in the working section can be sonic. It works on the induction principle where normally a primary air current from a compressed air reservoir is accelerated through slots into a mixing tunnel downstream of the working section of the tunnel. By virtue of its high velocity and its mass it here imparts momentum to the working fluid, thereby inducing the flow through the working section. The induced flow has a mass greater, and a velocity less, than the primary flow according to the geometry of the slots and the tunnel, and the speed at which the tunnel is being operated. The application of the jet turbine, with its high-velocity efflux to form the inducing flow, has made the induction form of tunnel particularly attractive economically for the kind of scale model investigations normally undertaken by aircraft firms with the relatively short operating periods involved. Its usefulness is particularly marked where the firm can provide its own engines and maintenance.

The new tunnel at Radlett employs three Rolls-Royce "Nene" engines, their arrangement being shown in Fig. 5; Fig. 6 overleaf shows the entry of the jet pipes in the mixing zone. These prime movers have the additional advantage of being easily and quickly started and avoid the imposition of the very high peak loads required in operating a 3ft to 4ft tunnel at high subsonic speeds. The arrangement is flexible also, in that the number of engines started can be reduced when the tunnel is working in the lower speed range.

The tunnel was designed by Handley Page technicians in collaboration with Rolls-Royce, Ltd., of Hucknall, which was primarily responsible for the injector layout, and testing of a one-tenth scale model used to check the performance of the tunnel. During the design stages suggestions from the Ministry of Supply, Royal Aircraft Establishment and the National Physical Laboratory were incorporated in the final arrangement.

The tunnel works on an open cycle, the combined primary and induced flow passing through diffusers to atmosphere.

There are several advantages to the method of mounting the engines external to the main duct, where only the jet pipes enter the duct system, rather than placing the installations in the return duct, as is done in certain other installations. Combustion air conditions for the engines are independent of the flow in the tunnel duct, and the engines are protected from damage if a model is carried away. The engines, being outside the tunnel, are maintained easily and may be inspected even when running.

To avoid condensation in the working section it is necessary to dry the incoming air, heat for which is readily applied by ducting part of the exhaust to a bank of hollow aerofoils in the intake and allowing the hot gas to mix with the incoming stream. Valves in the system vary the amount of recirculation.

The nozzle, working section and transition section of the diffuser are mounted inside a pressure cell to which they are vented (Fig. 3). This reduces the loading on their sides. Air enters the tunnel between a set of fifteen hollow aerofoils of 4ft chord and 3in constant thickness, with circular leading edges. They are fed from both ends with hot exhaust air. Internal vanes ensure that the hot air is evenly distributed into the tunnel intake through the open trailing edges of the aerofoils.

A settling chamber, 30ft long, lies between the heater aerofoils and the nozzle, which has a 12 to 1 contraction ratio. The octagonal working section, of 4ft by 3ft cross section, is 8ft long; boundary layer growth is compensated by varying the fillet size. The duct remains parallel in width between the entry to the working section and the end of the diffuser; only the depth is varied.

Beyond the working section a transition piece blends into the main diffuser, at whose end the duct turns through 90 deg., with a high aspect ratio bend, followed by a transition section of approximately constant area. A second 90 deg. bend follows; at this point the three jet pipes enter the tunnel.

After the second bend the duct changes from rectangular to circular section with constant cross sectional area over a length of 40ft. Beyond this point it remains circular with its area increasing towards the exit.

Here the exhaust silencer consists of two banks of absorbent splitters mounted in a rectangular duct. Ahead of the silencer is the hot gas re-circulation entry—an aerofoil with an open leading edge spanning the duct from roof to floor. The trunking which leads hot gases to the entry is fitted with cascades of aerofoils at each 90 deg. bend.

The three "Nene" engines are mounted vertically above one another and staggered in elevation to allow easy removal of any one. Combustion air is drawn into the engine-house through two banks of absorbent splitters, which reduce the noise outside.

The control room, alongside the engine-house, has double windows looking on to the engines. Here their controls are grouped and there is a telephonic link with the observation room.

Surrounding the tunnel working section is the observation room. It contains all the essential equipment for testing, including the six-component balance.

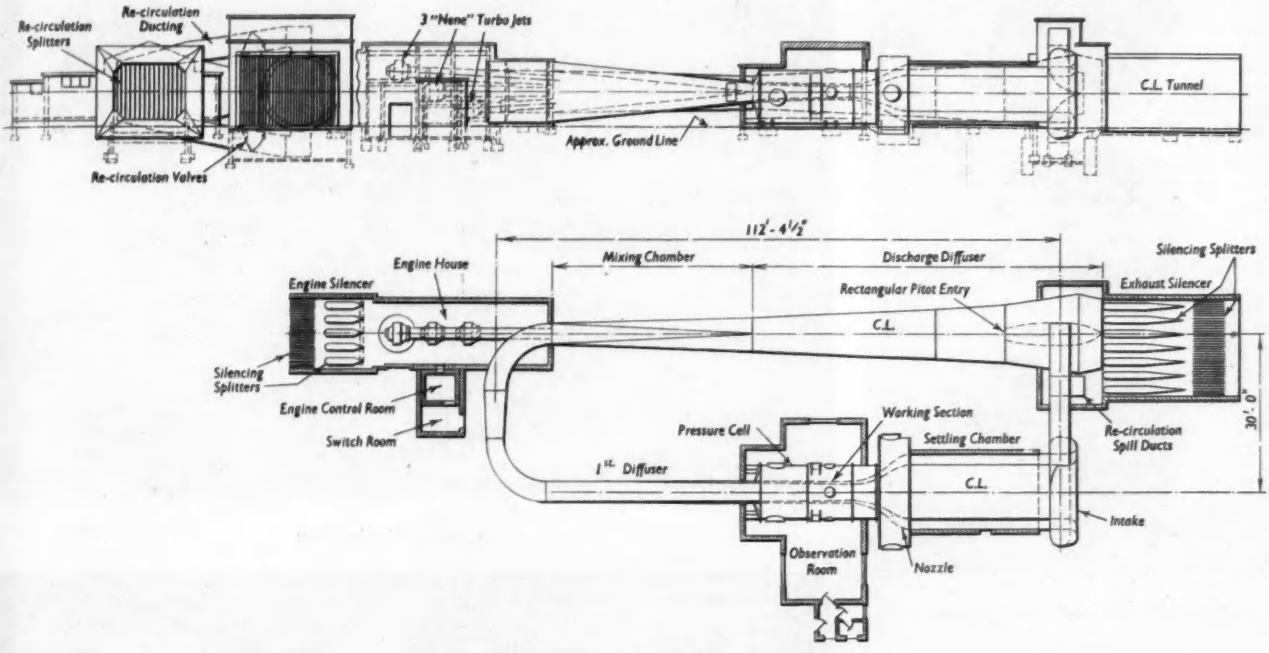


Fig. 5—General Arrangement of Tunnel Installation

Test House and Laboratories

Provision is made in the test house for all tests necessary for the development of the structure and airframes of large high-speed aircraft to be carried out in addition to research on new structural forms.

The test facilities are in al arge modern building, which gives 36ft clearance over a 30,000 square

feet floor. Along one side is a double-storey block of offices and laboratories.

The main test frame, designed by Handley Page technicians, is 50 per cent wider and higher than the famous "Cathedral" rig at the Royal Aircraft Establishment, Farnborough. Its length is the same, but it is designed to apply a higher maximum load, namely 400 tons (see Fig. 2).

This frame, used for structural tests on complete fuselages and wings, has its main load-reacting structure buried in the concrete floor. In this way there is unobstructed floor space beneath the frame and thereby easy access to and inspection of structures under test. Each of the many reaction points in the floor is capable of taking a 30,000-lb load.

Loads are applied by a hydraulic system which is electrically controlled. Measurement of the applied loading is by an independent hydraulic circuit. Strain gauge measurements in test specimens can be recorded on 800 channels.

A smaller frame, similar to the first, is used to test tail units and smaller structural components.

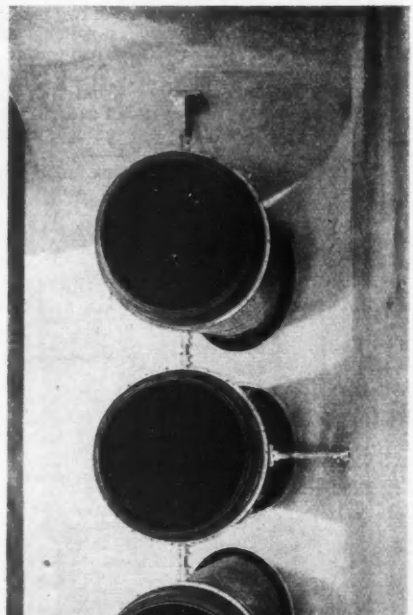


Fig. 6—Entry of Jet Pipes in Tunnel

Beneath, and closely spaced in the concrete floor, are many 30,000 lb load reaction points.

In one corner of the test house a specially strengthened floor with stanchions and overhead tackle is used for tests on seats, castings, doors and similar small components. Work of this type can also be carried out on a large L-frame with loads up to 20 tons.

Among the several testing machines installed are two Avery "universals" of 15-ton and 50-ton capacity, and one of Handley Page design used for compression tests—up to 200 tons—on structural panels. For fatigue testing there is a Losenhausen machine—with separate jacks and pulsator and a load range up to 300 tons static or 150 tons fluctuating—a Krouse machine of Handley Page design, with a load range of 1000–5000 lb, and an Ansler vibrophore for loads up to 4000 lb.

A water tank, 42ft long, 14ft wide and deep, is available for tests on fuselages.

The drawing-office and associated machine shop and fitting shop enable all rigs needed for functional testing of aircraft systems to be designed and built on the spot. In the case of the "Victor" full-scale rigs, which simulated the operation of its push and pull rod flying controls, air conditioning and fuel system enabled efficiency to be assessed before the first flight of the bomber.

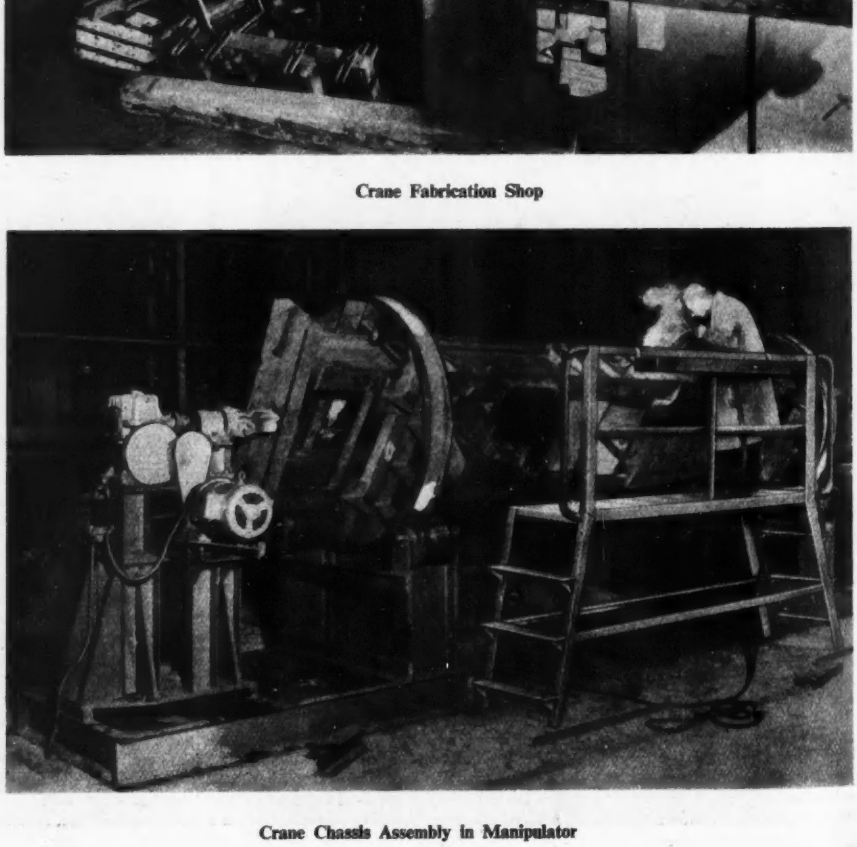
Other research facilities include well-equipped photographic, electronic, chemistry and instrument laboratories. It is in the electronics department that much of the measuring equipment used for tests is designed; that for the resonance tests of the "Victor" prototype is an example. Here, too, the balance and control gear for the high-speed wind tunnel was constructed. Work in the chemistry section is concentrated on metallurgical research and investigation of structural techniques such as spot welding and synthetic resin bonding. Calibration and maintenance of flight test instruments is also undertaken in the laboratory block.

Mobile Crane Works in Sunderland

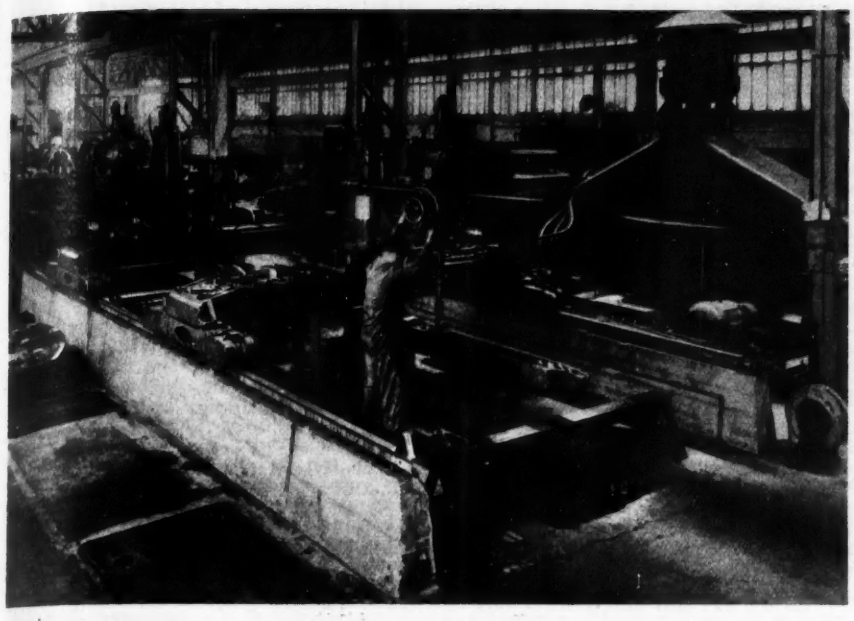
Following a decision made in 1945 to concentrate all production of "Coles" cranes at its Sunderland works, Steels Engineering Products, Ltd., has carried out in stages a comprehensive scheme of modernisation and extension. Output has been increased by the introduction of new methods in the fabrication, machine and assembly shops, whilst the range of cranes manufactured has been widened.

DURING the past few years steady progress has been made with a scheme of extension to increase the productive capacity at the Sunderland works of Steels Engineering Products, Ltd. This company, with a main works at Derby, in 1939 established a branch works at Sunderland for the production of "Coles" cranes and from then until 1945 produced them in substantial quantities at both works. When the war ended it was decided to concentrate crane production at Crown Works, Sunderland, and to use the Derby works for the products of an associated company. Once this decision had been reached plans were prepared for extensions which would not only make it possible to satisfy current requirements for mobile cranes, but would also allow for a further increase in production to meet the

Crane Fabrication Shop



Crane Chassis Assembly in Manipulator



Drilling Equipment for Large Members

steadily growing demands for mobile cranes by those branches of industry interested in mechanical handling of goods.

The scheme which was prepared covered a complete reorganisation of the works from the storage of raw materials to the painting of the finished cranes. It entailed re-equipment of existing shops with new machines, the introduction of new methods, replanning of work flow and the extension of key departments by new building. This work has, of necessity, been carried out in stages in order to avoid a drop in production, and because of the restrictions imposed by shortages of new machine tools, building materials, &c.

The four main sizes of "Coles" cranes now produced are of 6, 10, 15 and 20 long tons capacity and are made in the form of self-propelled mobile, lorry-mounted or rail units, incorporating standard and specially modified equipment to suit them for particular classes of work. All "Coles" cranes have electrically driven motions, power for which is supplied by an integral petrol or oil engine driven generator. The cranes are of all-welded construction, steel plate and standard sections being used throughout. A typical lorry-mounted crane of the firm's design was a 20-ton capacity machine illustrated and described in our issue of April 18, 1952. In addition to mobile cranes the firm also makes "Electric Eel" trucks, industrial tractors and electric hoists.

Crane manufacture is mainly concentrated in three large adjoining shops—a fabrication shop, a machine shop and an assembly shop.

The fabrication shop has a clear floor space 470ft long by 97ft wide. In this shop all raw materials are stored at one end, production being carried out in stages down its length. All materials and work in progress are handled by three 6-ton mobile cranes running in a wide, central gangway down the full length of the shop. Adjoining the material stock lines is a group of saws, punching, shearing, cropping, rolling, bending and similar machines which are used to prepare the steel sections and plates for the assembly stages at the lower end of the shop. The heavy steel plates which form the foundation of most of the fabricated units are shaped on a battery of flame profile cutting machines. The component parts formed and cut to close shape and size limits pass on to the main assembly area of the fabricating shop, some parts of which can be seen in the photograph we reproduce on page 148. Here the parts for the larger crane units, such as frames, rotating structure bases, &c., are tacked together in jigs before electric arc welding is carried out mainly by down hand working on power operated manipulators. The illustrations give some impression of the size and number of parts which go into the fabrication of some of the larger assemblies to be seen on the manipulators. The chassis of the 20-ton lorry-mounted crane, to be seen in course of fabrication on its manipulator, consists of four major assemblies and the final assembly incorporates 179 separate pieces. In the assembly of the main superstructure of a 20-ton mobile crane, which can be seen in progress on the left-hand side of the photograph of the shop, some sixty separate pieces are involved.

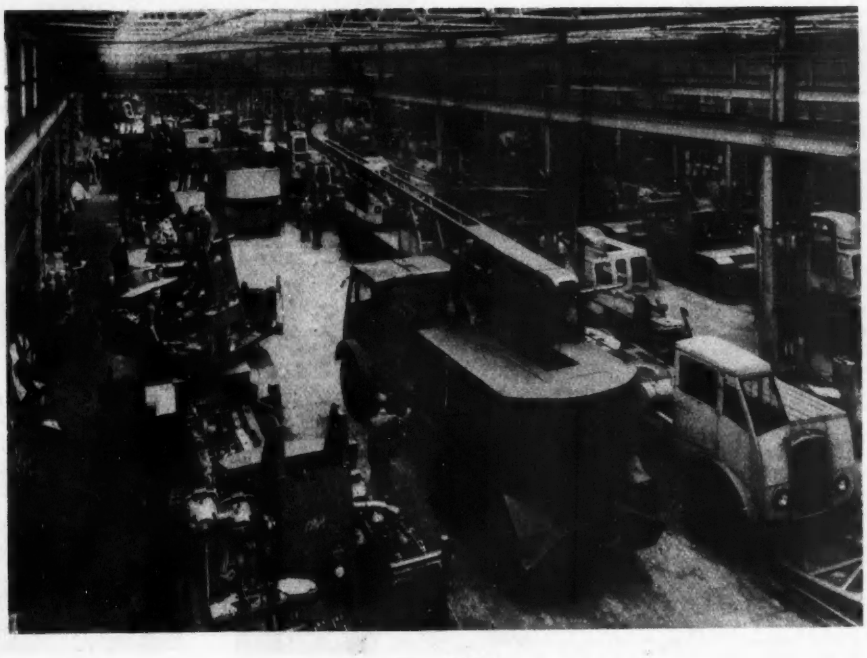
A close control of welding with accuracy of location and dimensions is called for in this assembly work, owing to the fact that many of the parts are highly stressed in service, and in order to keep subsequent machining operations within reasonable limits. Although the larger manipulators are installed at fixed stations, the main production area is kept clear of fixed plant to give a good margin of flexibility and permit easy rearrangement in accordance with current work flow through the department.

The sectional steel crane jibs and the "A" frames for cantilever cranes are assembled in a separate shop from parts supplied from the preparation section of the main fabricating department. The jibs are assembled on special jig tables and all welding is completed whilst they are on these tables. Tubular jibs are also made in a separate section of the works.

It should be mentioned here that all welding on any highly stressed parts, in addition to routine inspection, is examined by means of a portable X-ray equipment before the assemblies are dispatched from the fabricating shop.

The machine shop is a two-bay structure some 530ft long by 100ft wide. It is well equipped with modern machines suitable for handling work varying from main crane frames weighing about 4 tons and some 27ft long by 6ft 9½in wide, down to the quantity production of the smallest unit components required on the cranes. The variety in the size and nature of the work introduces certain problems in handling and organisation. For this reason the length of the shop is divided broadly into two parts—one end being devoted to the individual machining of heavy units and the other for lighter production machining. Production in the light machining section conforms to normal practice but in the heavy section some of the equipment and methods are of interest. A modern vertical grinding machine with an 8ft 6in diameter table and a boring mill with a 10ft diameter table installed as part of the re-equipment programme have been erected in pits with their tables level with the floor. These machines are largely concerned with machining of the rotating assembly bases, the largest of which are some 7ft 6in by 9ft 6in and weigh 2½ tons. By installing these machines in pits the problem of overhead clearance has been eliminated and the heavy parts can be skidded straight from the floor to the tables without need for lifting them to table level and manœuvring them into position whilst so suspended.

The height of the building introduced a problem in drilling the holes in the sides of the large crane chassis assemblies in the vertical position, as these chassis are some 27ft long and 6ft 9½in wide overall. Horizontal drilling equipment of special design would have been one solution to the problem but it was decided to introduce a means which would be suitable for drilling and tapping operations on a variety of other members rather than use a single purpose set-up not adaptable for other classes of work. The drilling equipment developed can be seen in an illustration on this page. It consists of a pit 28ft long, 6ft deep and 4ft wide. Walls 2ft high and supporting longitudinal



Crane Assembly Shop

runner rails set about 8ft apart are built parallel with the sides of the pit. Two rigid bridge members spanning the pit are supported at each end by carriages on the wall rails, and these bridges can be moved and locked in any required position over the working area. The upper surfaces of the bridges form the slide beds for two 3in capacity radial drills. A chassis for drilling is picked up by an overhead travelling crane and lowered sideways into the pit, where it is supported by means of parallels mounted between the floor plates at the pit sides. The bridges of the radial drilling machines can then be moved up and down over the pit and locked at the required stations for the drilling operations. When there are no chassis to drill other large units such as rotating structure bases, &c., can be supported on parallels over the pit for the various drilling and tapping operations to be performed without need for inter-operational movement of the member and its superimposed drill jig.

The crane erection shop is a modern three-bay building, 400ft long by 140ft wide, and in it practically the full length of two of the bays is devoted to the erection of cranes. The remainder of these bays and the whole of the third bay are used for the erection of sub-assemblies and the storage of components. Component parts from the stores are supplied as required to the sub-assembly points which, in turn, feed the main crane erection stations.

In the case of the self-propelled mobile cranes, each frame member is first set upside down and fitted with suspension, axles, transmission gear, &c., and, finally, the wheels. The chassis is then turned over on to its wheels and the slewing base is mounted in the frame ready for the erection of the crane superstructure. Before being set on its slewing base, the superstructure is built up as a unit with its generating plant, motors, gearing, hoisting, derricking and slewing machinery, control gear, &c., all bolted in place on the rigid fabricated platform. A jib, complete with its safe load indicator, sheaves, &c., is then positioned on the superstructure and its ropes rigged, before a complete prefabricated cabin is placed in position and bolted down.

All cranes are assembled in stages and progressively moved from station to station as successive units are installed. This method enables the sub-assemblies to be fed into the assembly line at fixed points adjacent to where they are built up. The firm also builds its own chassis for the lorry-mounted cranes, a separate section of the erection shop being set aside for their assembly. These chassis are also fitted upside down with suspension axles, wheels and transmissions, and are then turned over for mounting of engine, jib and slew base, &c.

As each crane is finished, it is driven to a test ground and subjected to a series of stringent running and operating acceptance tests. At the completion of these tests, the cranes are run into large spray booths and painted ready for delivery to their purchasers.

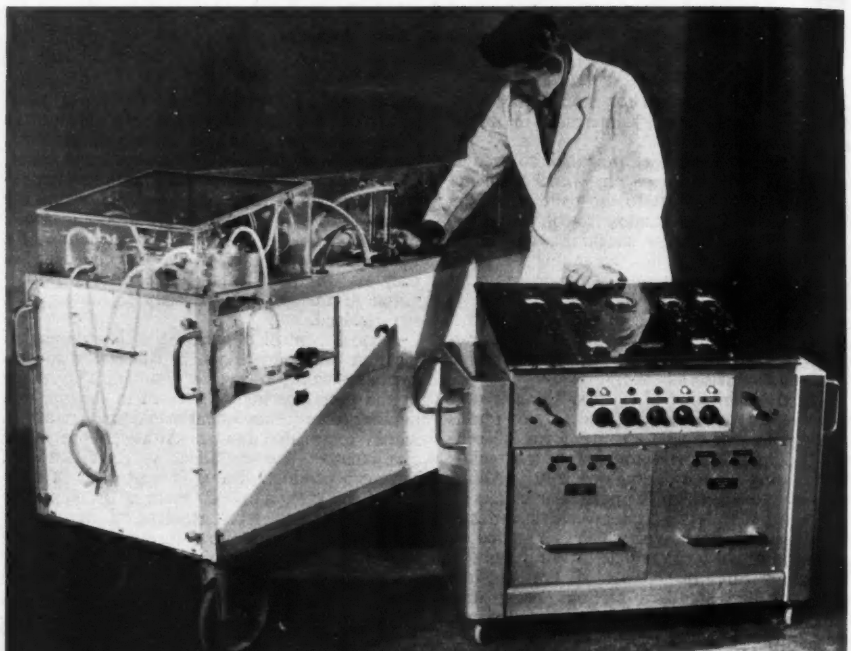
The works has its own iron foundry and forge shop and these, together with an associated steel foundry, make it independent of outside sources for all castings and forgings.

A short distance from the main crane manufacturing shops is a large shop built during the war. It is a modern building 400ft long by 250ft wide, complete with its own machine shop, sheet metal section, welding department, heat treatment section, assembly areas, &c. A large area of this shop is now set aside for crane work. Part of the sheet metal section provides all of the crane cabin structures which are jig assembled and sent as finished units to the main crane assembly lines. One side bay of the building is used for the erection of rail cranes, as this work does not readily lend itself to the normal methods followed on the main assembly lines, and often calls for the incorporation of special fittings best handled in a separate section. Another part of the shop is set aside for the manufacture of the "Electric Eel" trucks made by the company and, it might be mentioned, used extensively throughout these works.

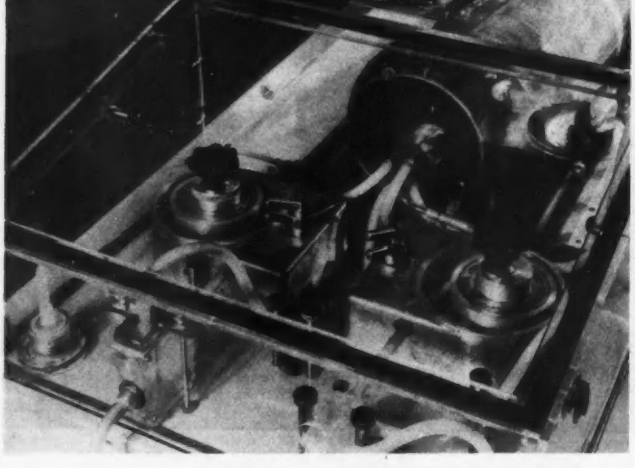
A Heart and Lung Machine

ONE of the interesting exhibits at the exhibition of electronic equipment held at the College of Technology, Manchester, from July 15th to 21st was a "heart and lung" machine developed by the Postgraduate Medical School of the University of London. The machine, which may be described as an extra-corporeal heart and lung, is designed to perform the functions of the human heart in pumping blood through the system, and of the lungs in oxygenating the venous blood. Briefly, these functions are performed by two rotary pumps which draw blood from the patient's body, pump the blood into an oxygenating cylinder and thence back to the arteries.

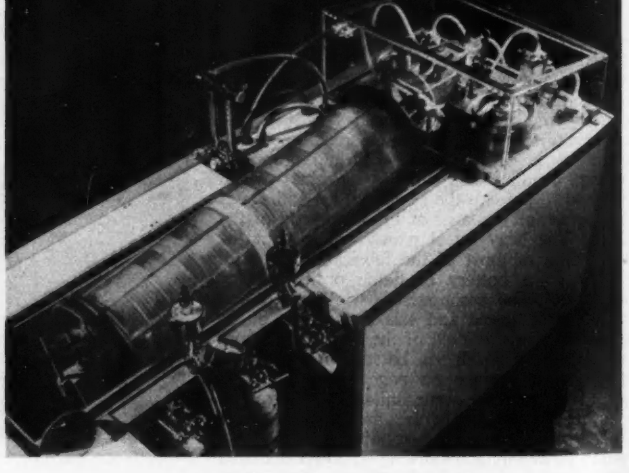
As illustrated herewith, the equipment is in two parts. The first is the oxygenator trolley which houses the pumps, oxygenating cylinder,



Extra-corporeal Lung and Heart Trolley and Control Cubicle



Rotary Pumps for Suction (Venous) and Pumping (Arterial) Pressures



Rotating Cylinder Forming Extra-corporeal Lung

gauges and the associated oxygen and carbon dioxide bottles ; it measures 6ft by 2ft 6in by 4ft 6in high and weighs 2½ cwt, ready for use. The second part of the machine is the control cabinet which measures 3ft 6in by 1ft 10in by 3ft 6in high. The oxygenator and its control cabinet are independently mounted on wheeled trolleys and are connected by flexible cables.

One of our illustrations shows the oxygenating chamber, which consists of a large rotating Polystyrene cylinder fitted internally with a large number of discs. When the machine is in operation this cylinder is fed with a controlled oxygen supply and with venous blood drawn from the patient. Rotation of the cylinder, combined with the effect of the large surface area presented by the discs, ensures that the maximum surface of blood is subjected to the action of the oxygen.

A close-up view of the two rotary pumps for the suction (venous) and pumping (arterial) pressures is reproduced in one of the illustrations. An essential requirement is that the equipment should provide for very close control of both the suction and pumping pressures and of the quantity of blood in the oxygenator cylinder. To satisfy these conditions the pumps are driven by variable speed electric motors which can be run from standstill to full speed under the control of English Electric " Magamp " power supply units. At the same time the blood pressures into and out of the oxygenator, as well as the blood level in the cylinder, are measured by special gauges incorporating differential transformers, the output voltages of which are used in combination to supply the control current to the " Magamp " units. Normally the oxygenator cylinder in its plastic casing is controlled to operate at blood heat. By pressing a button on the control trolley extra blood can be drawn from a transfusion bottle into the oxygenator, to make up the patient's blood loss as required.

Provision is made for the equipment to be operated under manual or fully automatic control. Pump speeds and blood pressures and blood level in the oxygenator are indicated by meters on the instrument panel of the control cubicle, and the operational danger limits are marked by warning lights.

The " Magamp " control system mentioned above consists, briefly, of a magnetic-amplifier circuit for giving accurate speed control (in either direction) of a d.c. motor fed from an a.c. supply. In this circuit the controlling medium is a transductor which, in conjunction with a full-wave bridge rectifier, provides the motor armature with a variable voltage d.c. supply, while a second bridge rectifier supplies the field windings with a fixed d.c. voltage. The " Magamp " units are installed in separate compartments inside the control cubicle.

We understand that the prototype equipment described here has been tested extensively with animals and that its performance has proved its fitness for use with human patients. It is evidently capable of being applied widely in resuscitation and in special treatments involving large-scale blood transfusion and it may assist in the development of new surgical techniques, especially in heart and lung operations.

The European Organisation for Nuclear Research

A STATEMENT from Unesco recalls that the Convention for setting up the European Organisation for Nuclear Research was signed in Paris on July 1, 1953. Representatives of twelve European nations participated, namely, Belgium, Denmark, France, the German Federal Republic, Greece, Italy, The Netherlands, Norway, Sweden, Switzerland, the United Kingdom and Yugoslavia. The Convention will take effect when the signatures have been ratified by the Governments of Switzerland (the host country) and six other nations.

The purpose of the European Organisation for Nuclear Research, as stated in the Convention, is to " provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto." The Organisation is to have " no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available."

The basic programme of the Organisation, according to the Convention, will be " the construction and operation of an International Laboratory for research on high-energy particles, including work in the field of cosmic rays " ; also " the organisation and sponsoring of international co-operation in nuclear research, including co-operation outside the laboratory." Among the activities specifically mentioned are co-operative work in nuclear physics and in cosmic rays, the promotion of contacts between and interchange of scientists, the dissemination of information, and the provision of advanced training for research workers.

The laboratory will be housed on a site approximately 600 metres square about 3 miles north-west of Geneva, Switzerland, and adjoining the French border. This site was offered by the Canton of Geneva Government. The construction of the buildings and the arrangements of the site are expected to take three years and to cost about 23,000,000 Swiss francs. The laboratory will contain a synchro-cyclotron capable of accelerating protons up to approximately 600 million electron volts, which will be ready for operation in 1957 and will cost 17,000,000 Swiss francs. Meanwhile, the most powerful proton-synchrotron ever planned will be under construction to be ready for use in 1960. It will provide energies above 10,000 million electron volts, and will cost about 55,000,000 Swiss francs. Actually, the designers are aiming at 30,000 million electron volts. Its circular magnet will be about 300m in diameter and will be underground.

The cost of all activities, including construction and installation during the first seven years, is estimated at 120 million Swiss francs (28,000,000 dollars or £10,000,000 sterling). The funds will be provided by the member states on a relative scale based on their average net national incomes. This scale will be revised every three years on the basis of the average income for the preceding three years, but no one state will pay more than 25 per cent of the total. For the period until the end of 1956 the scale adopted is as follows :—Belgium, 4·88 per cent ; Denmark, 2·48 per cent ; France, 23·84 per cent ; German Federal Republic, 17·70 per cent ; Greece, 0·97 per cent ; Italy, 10·20 per cent ; Netherlands, 3·68 per cent ; Norway, 1·79 per cent ; Sweden, 4·98 per cent ; Switzerland, 3·71 per cent ; United Kingdom (Great Britain and Northern Ireland), 23·84 per cent ; Yugoslavia, 1·93 per cent. However, Greece and Yugoslavia, with low *per capita* incomes, asserted their inability to meet this scale and special provision was made for them during this first period. Greece will pay 0·35 per cent and Yugoslavia 0·65 per cent. These reductions leave 1·9 per cent unassigned which will be assumed voluntarily by eight of the ten other nations (all except Italy and Sweden) in the proportion of their basic shares.

Other states may become members of the Organisation in the future, but only by unanimous vote of the member states. The governing body of the Organisation will be a council in which each member state has a single vote, but may be represented by not more than two delegates. The council will meet at least once a year. It will, by a two-thirds majority, appoint a director as responsible executive. After seven years, any member state may withdraw from membership at the end of any financial year.

European Council for Nuclear Research

The European Council for Nuclear Research (C.E.R.N.), will automatically go out of existence when the European Organisation becomes a legal reality. It may be recalled that the council was established by an agreement which was signed at Geneva in February, 1952, and came into force on May 2, 1952, to undertake the planning and organisational work of establishing the Organisation. It was itself organised at the initiative of Unesco.

The 1950 General Conference of Unesco in Florence adopted a resolution introduced by the United States delegation which instructed the Director-General " to assist and encourage the formation and organisation of regional research centres and laboratories in order to increase and make more fruitful the international co-operation of scientists in the search for new knowledge in fields where the effort of any one country in the region is insufficient for the task." It authorised initial surveys of cost estimates and location and " help in the formation of programmes without contributing to the cost of construction or of maintenance out of Unesco's regular budget."

Under Professor Pierre Auger, Director of Unesco's Department of Natural Sciences and Professor of Quantum Physics at the Sorbonne, the initial surveys were carried out during 1951 which led to the establishment of C.E.R.N. in 1952. Ten European states became members, the same that are now joining in the Organisation, except for the United Kingdom and Greece. The United Kingdom, however, was represented at all meetings and contributed to the budget without formal membership. C.E.R.N. has operated to date on a budget of 1,073,445 Swiss francs (245,000 dollars or £87,000), contributed as follows :—Belgium, 87,145 francs ; Denmark, 35,000 ; France, 312,400 ; German Federal Republic, 152,000 ; Italy, 109,000 ; Netherlands, 43,500 ; Norway, 22,000 ; Sweden, 48,000 ; Switzerland, 100,000 ; Yugoslavia, 43,500 ; United Kingdom, 120,900.

There have been six sessions of the council, successively in Paris, Copenhagen, Amsterdam, Brussels, Rome and Paris. What will presumably be its final session will meet at Geneva in October. Professor Edoardo Amaldi, of the University of Rome, has served as Secretary-General, with Professor P. Scherrer, of Switzerland, and J. H. Bannier, of The Netherlands, as successive chairmen. Sir Ben Lockspeiser is chairman of the administrative and financial committee. Four active study groups have been in charge of the detailed planning on which the Organisation would be based. Their Directors are Professor Niels Bohr, of Copenhagen, for the theoretical investigations ; Dr. Lew Kowarski, of the French Atomic Energy Commission, for the planning and equipment of the laboratory as a whole, the Norwegian engineer, Odd Dahl, of Bergen, for the design of the large proton synchrotron, and Professor C. J. Bakker, of the University of Amsterdam, for the design of the synchro-cyclotron.

At their last meeting, which took place in Paris on June 29 and 30, 1953, the member states of C.E.R.N., which was originally established for a period of eighteen months ending November, 1953, signed a supplementary agreement extending the life of the council to November 1, 1954, or until the Organisation is established, whichever is earlier. Then the council will hand over to the Organisation all its resources.

The council voted 1,000,000 Swiss francs (233,300 dollars or £83,000) to provide for expenses until January 31, 1954. Member states were assessed as follows :—Belgium, 49,900 Swiss francs ; Denmark, 25,300 ; France, 243,500 ; German Federal Republic, 180,500 ; Italy, 104,000 ; Netherlands, 37,600 ; Norway, 18,300 ; Sweden, 50,900 ; Switzerland, 38,000 ; Yugoslavia, 8500. To this will be added a non-member contribution from the United Kingdom of 243,500 Swiss francs.

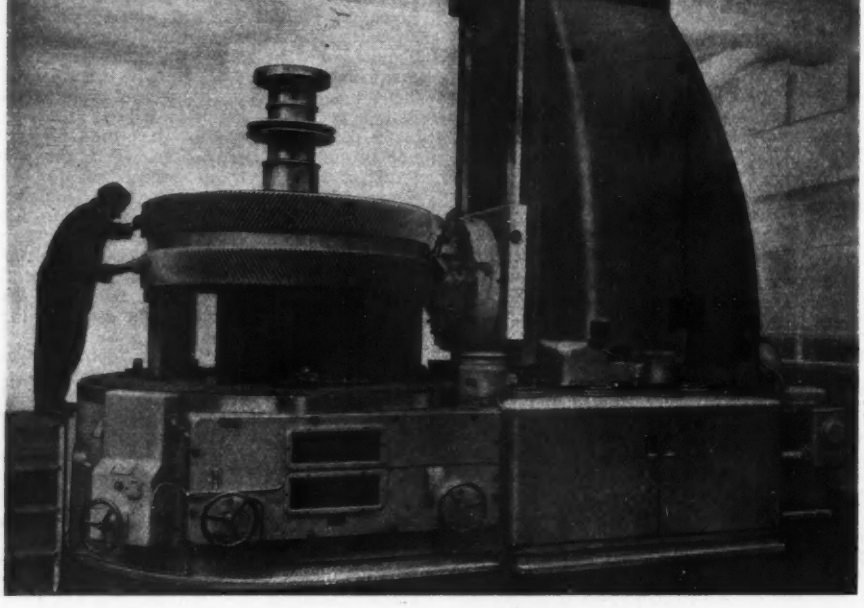
Unesco's function was to initiate the project, to bring the nations together, to advise in the plans and then to withdraw when the Nuclear Council was established, though it has continued to co-operate closely and has acted as host to meetings and to the laboratory study group. Now the council itself is to be succeeded by the permanent European Organisation for Nuclear Research where the twelve nations combine their resources and start on a joint exploration of the possibilities offered by researches on the fundamental particles.

FAN FOR RESISTING CORROSIVE CONDITIONS.—The recently introduced " Airflo Resista " fan made by the Industrial Fan and Heater Company, Ltd., of Birmingham, 11, is designed to resist the corrosive action of strong acids, alkalis and moist gases. The impeller of this fan is constructed of rigid P.V.C. and all necessary metal parts are completely protected, the casing itself being fully lined with P.V.C. bonded to the outer shell of mild steel. This fan is for use only where temperatures do not exceed 60 deg. Cent. or 140 deg. Fah.

A 110in Gear Hobbing Machine

A PHOTOGRAPH we reproduce on this page shows a 100in turbine gear hobbing machine which is the first of a new standard range of large turbine wheel machines being built by David Brown Machine Tools, Ltd., of Manchester, to British Standard Specification No. 1498 : 1948. The machine has been installed and is now in production at the works of David Brown and Sons (Huddersfield), Ltd.

In sending us particulars of this machine the makers point out that the B.S. Specification to which it complies embodies all previously accumulated experience on the production of high-grade gears for turbine and similar drives. Prepared under the authority of the Mechanical Industries Standards Committee, in conjunction with the Admiralty, the National Physical Laboratory, Lloyd's Register of Shipping and principal gear manufacturers, this specification covers two classes of machine, Grade "A" and Grade "B." The Grade "B" classification requires a high quality of normal production from machines producing gears running under normal loading and pitch-line velocities. The Grade "A" specification, with which the new 100in machine conforms, applies to machines



Precision Gear Hobbing Machine

designed for the production of relatively heavily loaded gears with high pitch-line velocity.

The machine is designed to cut gears from 28in to 100in diameter with a maximum pitch of 2 D.P. It has a vertical hob slide traverse of 70in, the maximum centre distance from hob to table being 68in, the table being 108in diameter with a 14¾in bore. The hob slide has a maximum vertical traverse of 70in at speeds from 0·007in to 0·070in per revolution of the table. Hob speeds from 20 to 100 r.p.m. are available and the power infeed is 0·0125in per revolution of the table.

The table drive incorporates two independent dividing worm wheels ; one is a fine pitch master wheel, which is used to apply the finishing cut, and the other is a coarse pitch wheel used principally for roughing. The coarse pitch wheel is used during setting up of the machine and can be coupled to an independent motor when it is required to rotate the table at a relatively fast rate.

The fine pitch master worm wheel has 800 fine pitch teeth, giving a continuous engagement with the mating worm to ensure accuracy of division and surface finish of the finished gear. This wheel is split at right angles to its axis and through the centre of the teeth. One-half of the wheel is rotated relative to the other between semi-finishing cuts and, by a process of measurement and further cutting, greater adjacent and accumulative accuracy of pitch is achieved.

Vertical travel of the hob is effected by a large screw which was finished on the maker's master screw-cutting lathe to limits of accuracy demanded by the B.S.I. specification and certified by the National Physical Laboratory. Adjustment of this lead screw is by means of two nuts, one of which is fixed and the other adjustable. A large seating on the hob saddle locates the hob slide, which can be swivelled through 180 deg. to accommodate right or left-hand helical teeth.

The hob driving spindle, on which is mounted the flywheel, is located in the final driving gear by multiple splines. A conical bearing at the front end of the spindle designed to facilitate the accurate alignment of hob and spindle, has axial adjustment by which any errors due to excessive clearance can be quickly rectified. When centralising the hob, axial adjustment is made by means of a rack and pinion in the bracket which carries the conical bearing.

Because of the wide range of gears within its cutting capacity the machine is designed so that part of the load on the table is counterbalanced by hydraulic pressure. This counterbalance pressure can be adjusted to suit individual gears and it enables a constant bearing pressure to be maintained, irrespective of the gear weight.

The main gearbox, incorporating the change gears for the feed, spiralling, indexing and prime mechanisms, is situated at one side of the machine, whilst hob speed change gears are housed separately at the opposite side.

Oil is supplied to the table unit by two 1 h.p. gear pump motors mounted in tandem. One pump supplies oil to the table load relief, whilst the other feeds lubricating oil to the two sets of dividing gears and the main gearbox. The gears and bearings in the hob slide are automatically and continuously lubricated. A third gear pump is used to circulate the cutting oil.

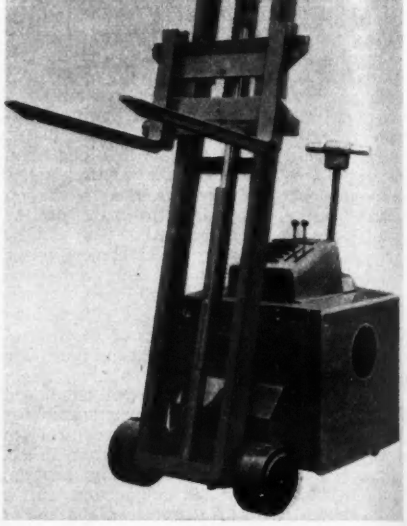
All the electrical control equipment is housed in a self-contained cabinet. The 10/20 h.p. variable speed main motor and 1 h.p. lubricant and coolant pump motors are arranged for d.c. supply, so that in case of a power failure the drive can be switched to a secondary source, such as a battery set, to ensure uninterrupted cutting.

In addition to the 100in machine illustrated, the range of turbine wheel hobbers being made by the firm to conform to B.S.I. Specification No. 1498 : 1948 (Grade "A") includes a 150in machine, capable of hobbing turbine gears from 56in to 150in diameter (maximum pitch 2 D.P.), and a 200in hobber with a capacity of 90in to 200in (maximum pitch 1¼ D.P.). Both of these machines are of similar design to the 100in machine, with the exception that, in the case of the 200in hobber, swivelling of the hob slide is power operated.

A Pedestrian-Controlled Fork Lift Truck

A RECENT addition to the range of fork lift trucks made by Lansing Bagnall, Ltd., of Basingstoke, is the electrically operated pedestrian-controlled unit. This machine has a lifting capacity of 1000 lb at 15in centres from the heel of the fork, and its overall dimensions have been kept low to suit it for use in congested conditions and limited spaces, such as exist in many warehouses, stores, &c.

As can be seen in the illustration below, the driving controls of the machine are accessibly located in the handle head and they consist of a twist grip speed control, giving infinitely variable speeds from 0–4 m.p.h., with a preselective reversing switch. The lift and tilt controls for the forks are situated within easy reach and so is an immobilising key switch.



Pedestrian Controlled Fork Lift Truck

The complete drive unit, consisting of the handle, motor, control box and gearbox, is mounted in a double ball track bolted to the main frame. This driving unit follows movements of the control handle and steers automatically through 200 deg. On release the control handle automatically returns to a vertical position and applies the brake, and similarly the twist grip also returns to the off position as soon as the handle is released.

The brake is applied direct to the worm shaft and its operation is automatic in the horizontal and vertical position of the control handle through the action of a cam on the handle shaft.

A regenerative braking system, which limits the speed of the truck on ramps and downgrades, also serves as an effective brake at all speeds down to 1 m.p.h. to reduce wear on the mechanical braking system.

The truck has a single lift of the forks of 67in, the lifting speed being from 18ft to 22ft per minute. The forks can be tilted from 10 deg. backwards to 2 deg. forwards.

SCHOLARSHIPS IN RUBBER TECHNOLOGY.—The British Tyre and Rubber Company, Ltd., has endowed scholarships at the National College of Rubber Technology, in London, which will be known as "B.T.R." Scholarships. A scholarship will be awarded annually and each will be for three years and valued at £300 per annum.

The Industrial Applications of Radioactive Materials

By Sir JOHN COCKCROFT, K.C.B., C.B.E., M.I.E.E., F.R.S.*

We reproduce abstracts from the Sir Alfred Herbert paper presented at a meeting of the Institution of Production Engineers at Oxford on July 24, 1953. In this paper Sir John Cockcroft outlines the varied uses of radioactive materials in industry and touches on some of the interesting possibilities in chemical engineering He concludes by indicating the facilities available at Harwell for producing isotopes and for giving technical advice about their use.

THE radioactive elements have two distinguishing characters. First of all, the average time they exist before changing their nucleus varies greatly—we specify this by a so-called half life, the time during which half the nuclei will change over ; second, by the characteristics of the radiations they emit in the process. The half lives of radioactive elements range from micro seconds to millions of years. The radiations, whether of electron or gamma rays, are specified by giving their energy in electron volts. Thus, radio cobalt, which is much used in radiography, has a half life of about five years and gives out gamma rays of a little over 1,000,000 electron volts energy. The energy of the radiation determines its penetrating power and the cobalt radiation will penetrate in a useful way 2in to 6in of steel.

Radioactive elements were created in a wide variety in the initial creation process of our universe, about 3 billion years ago. Since that time most of the short-lived elements have returned to stability, leaving, however, a few important radioactive elements, particularly amongst the heavy elements. The best known amongst these are uranium and radium, but there remain altogether sixteen of the radio elements created by Nature. Radium has a half life of 1600 years and gives rise to a chain of unstable daughter products, some of which—such as radon—are useful to industry. The first application of radioactive elements to industry came, therefore, from the use of radium and its decay products.

Most of the radio elements available to industry are now made in an atomic pile, and the Harwell pile is now a principal source of creation of these elements. The pile consists of a pile of very pure graphite blocks between which are spaced 20,000 bars of uranium metal, clad in aluminium. The uranium nuclei split up at a controlled rate and throw out neutrons which split up more uranium nuclei in a so-called chain reaction. Heat equivalent to about 6000kW is developed in the uranium metal bars ; powerful gamma rays are emitted and neutrons fly about in all directions at high speeds. The uranium nuclei split up into two fragments which are usually radioactive. So amongst the waste products of the pile—the so-called fission products—we have at least thirty kinds of radioactive elements.

For the most part, however, we use the neutrons flying about in the pile to create new elements. The neutron enters a nucleus and thereby increases the number of neutrons by one. This new nucleus will often be unstable and so a radioactive element has been created. For example, if we put cobalt wire or rod in the pile, a cobalt nucleus of atomic weight 59 turns to cobalt 60, which emits the penetrating gamma rays I have spoken about.

So, each Monday morning we load into the B.E.P.O. a large number of aluminium cans containing materials which are to be transformed into radioactive elements. A general view of the loading arrangements is reproduced in Fig. 1 and a close-up of a portion of the loading conveyor is given in Fig. 2, in which the lead shielding has been removed to show the graphite stringers and holes for the aluminium cans. They will remain in the pile for varying periods. The elements of long half life, such as cobalt, stay in a long time because the radioactivity builds up steadily for a period comparable with their half life. Short-lived elements will stay in for periods of a week or so and Monday morning sees a great activity in discharging these elements. Figs. 3 and 4 illustrate this.

RADIOGRAPHY

The industrial applications of radioactive elements are now in an interesting growing stage. The oldest application is to radiography, since radon, the gaseous daughter of radium, has long been and is still used for this purpose. The penetrating X-rays from the radioactive products are used to take photographs similar to X-ray pictures, to show up deficiencies in castings, forgings, welds, and assembled products. The radioactive elements provide a wide range of radiations which can be chosen to suit the job. At one end of the energy scale the radiations from thulium 170, which have the modest energy of 85kV, are very suitable for radiography of light alloys, since great penetration is not required and good contrast is obtained. Radio iridium (192) emits gamma rays of 600kV maximum energy and is useful for thicknesses of steel between ½in and 2in. It can be obtained in very strong sources and is used widely for testing of welded boiler plates and steam pipes. A typical technique is to insert the small source on the axis of a pipe and to wrap a flexible cassette of film around a peripheral weld. A fifteen-minute exposure will then reveal the whole weld in a picture that can be shown to the welder. When I was in New Zealand I visited a new hydro-electric station and was interested to find that faulty welds in some of the penstocks were being radiographed on the site by the use of radio iridium sources flown out in seven days from Harwell. The radio iridium has the advantage of high intensity for a given price, but loses half its activity in seventy days and has to be returned to the pile to be reactivated. Radio cobalt has a longer half life of 5·3 years and emits gamma rays of 1200kV energy. It is therefore useful for steel thicknesses of up to 6in.

Radiography can also be used to check the assembly of mechanism inside opaque cases.

Fig. 1—Loading and Unloading of Pile

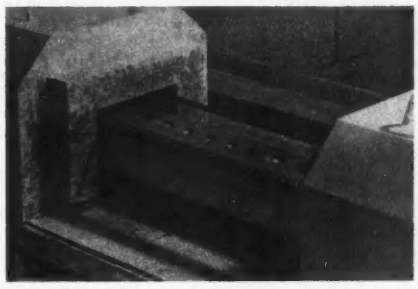


Fig. 2—Graphite Stringers and Holes for Aluminium Cans

Radioactive elements can also be used to show up fine surface cracks in metals. An experiment was carried out for the de Havilland Aircraft Company, who wished to search for fine cracks in propeller metal. So a solution of radio phosphorus—which emits electrons—was made in a detergent in order to reduce the surface tension. The solution thus spread uniformly over the surface. After removing the surplus a photographic film was put in contact with the metal surface. Since the radio phosphorus solution had penetrated the cracks, the film was blackened in the position of the cracks. This is the method of radio autography.

The number of electrons transmitted by materials depends on the thickness of the material, its density and the energy of the electron. We can therefore measure continuously the thickness of strip as it comes from the rolling mill, by placing a radioactive source emitting electrons on one side of the strip and a meter to measure the electron intensity on the other. Gauges of this kind are in use commercially for the measurement and continuous thickness control of steel, brass, copper, cardboard, plastic film and paper. Thallium 204 is used for materials having weight up to about 120 milligrams per square centimetre. Strontium 90 emits more penetrating electrons and is used up to four times greater density of material—up to ¼in aluminium, for example. For still heavier materials gamma rays from iridium can be used.

Radioactive gauges can also be built to measure the thickness of plating, such as tin plating. The electrons from a radioactive source are scattered backwards into a counter, mainly by the tin layer, which is heavier than the substratum. By such a device the thickness of the tin plate can be measured with an accuracy of 1/100,000in. This obviously enables great control and economy of material to be obtained.

This same method of back scattering can be applied to measure the wall thickness of steel tubes having diameters of 2in upwards and a wall thickness of 0·1in to 1in. Quite small sources can be used and measurements of wall thicknesses can be made with an accuracy of 3 per cent to 4 per cent. This enables the corrosion of tubes to be followed.

There is a possibility that coal can be separated from shale by taking advantage of the different scattering of gamma rays. Thus, in a preliminary test it was found that the radiation from thulium was back scattered about 25 per cent more from coal than from shale. A belt conveyor would

* Director, Atomic Energy Research Establishment, Harwell

carry the coal plus shale and an ejector would get rid of the shale automatically.

Ionising Properties of Radiation

When high-speed electrons pass through gases they displace electrons from the atoms of the gas and leave it in a so-called ionised state which conducts electricity, since the displaced electrons can move freely in an electric field.

This property can be used industrially to conduct away troublesome electric charges. This happens, for example, in the weaving of some fabrics such as nylon. The fabric collects electric charges and thus attracts dirt and produces marks. If the air is made conducting by a radioactive source the electric charge leaks away and marking is prevented. Static eliminators have been developed by the Shirley Institute, using radio-thallium or radio-strontium incorporated into a silver foil.

This property of ionising gases is also useful in helping cold-cathode valves to become conducting at a consistent voltage. So a little radioactive hydrogen is introduced into the valve and then taken out again, but leaving enough behind on the walls to throw out sufficient electrons to produce the requisite amount of ionisation.

Process Control

Radioactive materials can be used for a wide variety of process controls, by making use of the extremely sensitive methods available for their detection—methods which can detect as little as 10^{-12} grammes. In one interesting example a cattle food manufacturer was adding a very small trace of a vitamin to a large amount of cattle food and it was difficult to establish if his mixing process was adequate enough. So a small amount of radioactive sodium chloride was added to the vitamin before mixing. The food was then added to a conveyor belt, where a counter indicated the activity and showed directly whether the mixing was uniform.

The Chemical Engineering Division at Harwell has used radioactive tracers to control separation processes. Hafnium and zirconium occur together in nature and have to be separated to produce zirconium metal suitable for atomic piles. This can be done in an ion exchange column. A little radioactive zirconium and hafnium is added to the material to be separated. The two materials are first adsorbed on the ion exchange resin until the resin is saturated. At this stage radioactivity begins to appear at the bottom of the column. A washing out agent for one material is added and it is possible by measuring the radioactivity to measure how much of it is removed. When the greater part of this constitution has been washed out the second washing out agent is added and so the second material is separated.

Fig. 3—Radiated Isotopes Being Loaded into Lead Trolleys

Leakage and Penetration Testing

The ease with which small amounts of material can be detected by their radioactivity makes it possible to use radioactive tracers as leak detectors. Radio sodium is dissolved as sodium carbonate in water at quite low levels of activity and inserted into a leaking water main. Measurements are then made of ground water samples with a radiation counter. It proved to be possible to detect leaks as small as one pint per hour.

Leaks in underground cells can also be detected by radioactivity. In France, a number of long-distance telephone cables contain paper-insulated wires in a jute-covered lead envelope under 0·8 atmosphere of nitrogen. Any hole in the lead envelope would be disastrous if not detected and repaired before water has time to leak in. The approximate position of the leak can be found by pressure fall methods. A radioactive gas, methyl bromide with radiobromine, is then injected. The leakage can then be detected by instruments carried above ground by a man walking at a brisk pace.

Use of Radioactive Sources as Markers

It is often necessary to determine the position of objects in underground borings or pipelines. Thus a 50-mile pipeline in Scotland had to be cleared before admitting oil. This was done by a scraper ("Go Devil"). If it got stuck it would be very difficult to locate the exact position, so a small source of radio cobalt was attached, which could easily show up the position.

In drilling vertical and horizontal boreholes for underground gasification work it was desirable to measure the miss distance of the two bores. So a radio cobalt source was put in one bore and a radiation meter in the other, enabling the miss distance to be measured with an accuracy of a few inches.

In a similar way the arrival of the interface between two batches of oil in a pipeline can be determined exactly, so that the new batch of oil can be diverted to a separate tank.

Application to Chemical Engineering

In addition to those proved applications of radioactive materials to industry, new and larger scale applications are beginning to appear on the horizon, with the coming advent of much larger radioactive sources.

The applications I have described so far have required radioactive sources having an activity at the most equivalent to that of a gramme of radium.

We can now produce radio-cobalt or radio-iridium sources having an activity 1000 times higher—we call this a 1000 curie source. We can also envisage within two or three years extracting from radioactive waste products sources of radio-caesium 100,000 times greater than 1 gramme of radium.

We are at present using a 300 curie radio-cobalt source at Harwell to study the effect of radiation on chemical reactions. In these reactions gaseous products, such as ethylene, are transformed by high temperature and pressure in the presence of a catalyst into a polymer, such as polythene. Now it turns out that these reactions will take place in the presence of radiation without the high temperature. This might result in production economies.

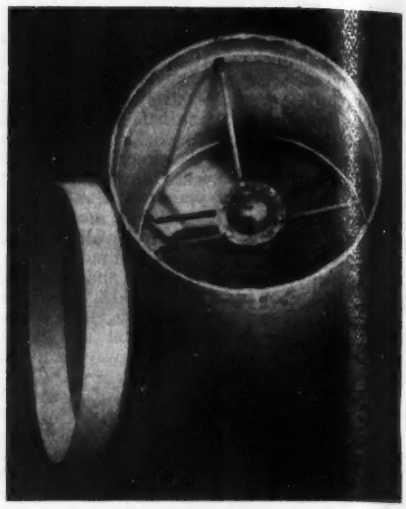


Fig. 4—Packing Container for Isotopes

Radiations can also change the properties of the polymer by producing more cross linkages in the molecule.

Applications to Industrial Research

Many applications to industrial research have been found which make use of the great sensitivity of methods of detection of radioactive elements.

Thus, Messrs. Courtaulds wished to determine the distribution of lubricant, used in spinning nylon thread, along the thread. So a little radioactive methyl bromide was added to the lubricant and after spinning the fibre was placed over a photograph film. On development the film was blackened in proportion to the intensity of the radioactivity which in turn was proportional to the thickness of lubricant at that point. As little as 10^{-10} grammes lubricant per centimetre of fibre length could be detected.

Annual Shipments of Isotopes from Harwell, United Kingdom

	1947	1948	1949	1950	1951	1952
Hospitals	5	49	904	1669	2801	3354
Universities	36	435	464	769	810	797
Industry...	—	19	88	436	533	602
Government Departments	25	59	184	137	398	217
Agriculture and others	4	13	11	25	34	36
A.E.R.E.	65	764	1063	1273	1783	1396
U.K. total	135	1379	2714	4309	6359	6402

Lubrication research studies have been facilitated by making a piston ring radioactive by exposing it in a pile. The radioactive iron of the piston ring is rubbed off and appears in the lubricant and on the cylinder wall. The amount of this can easily be measured by a photographic film in the case of the cylinder wall, and by an electrical counter for the lubricant. In these studies the wear of 10^{-7} grammes could be measured. By this very sensitive method the time to obtain results is greatly reduced. Similar studies have been carried out on commercial passenger aircraft. The occurrence of excessive

wear of moving parts can be detected at an early stage. This may well simplify the problem of maintenance.

Factories carrying out operations on toxic products requiring special ventilation arrangements to ensure that tolerance breathing doses are not exceeded can make use of radioactive gases to check the dispersion of the air used for ventilation. A radioactive gas is introduced at this point and measurements are made at other parts of the building to ensure that the system is effective.

The accompanying table shows the growth of industrial applications of radioactive elements. Although their use is developing rapidly, we feel that we are only at the beginning of such beneficial uses.

Industrial organisations interested in using these new tools can obtain advice from the Industrial Applications Group of the Harwell Isotope Division, which is always prepared to give advice and on occasions to make preliminary investigations of possible applications for a modest fee. This relieves the industrial organisation from the necessity of buying electronic equipment before the application is proved.

We are also prepared to train industrial staff at our Isotope School, which runs four-week courses at regular intervals. This school teaches techniques and also deals with the elementary health precautions which are necessary for those using radioactive materials. These health precautions are simple and standardised and no organisation need be deterred from using radioactive elements for " fear of the atom."

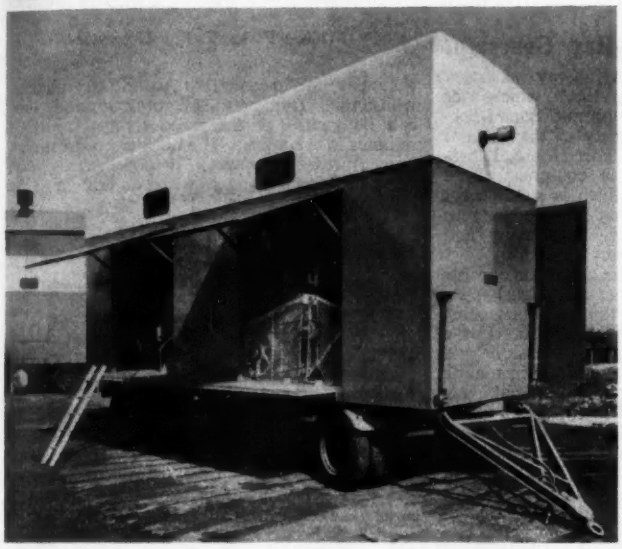
The accompanying illustrations are Crown Copyright, reproduced by permission of Her Majesty's Stationery Office.

Portable Grain Handling Equipment

WE have received from Simon Handling Engineers, Ltd., of Cheadle Heath, Stockport, particulars of a number of interesting portable grain handling equipments which it has designed and built for the Turkish Government. The construction of these equipments was decided upon by the Turkish Government because that country had a surplus of grain available which was far more than could be dealt with by the existing storage and handling facilities at the grain shipping ports. To meet the situation until permanent installations could be built, the Turkish Government in 1952 decided on an interim handling and storage system involving the use of prefabricated huts and a fleet of road trailers carrying grain handling, cleaning and weighing machinery. The scheme was designed not only to provide emergency handling and storage facilities but also to substitute bulk handling and storage for the laborious manhandling of grain in sacks.

At the invitation of the Turkish Government, Simon Handling Engineers, Ltd., submitted designs of suitable types of portable handling equipment and in June, 1952, received a contract to the value of more than £500,000 for forty-eight special trailer-mounted units. These units have been designed to serve four purposes ; first, they will discharge grain arriving at the ports in road and rail vehicles into bulk storage in huts ; secondly, they will " turn over " grain from one hut to another if this should be necessary to keep it in condition during prolonged storage ; thirdly, they will load grain from the huts into road and rail vehicles for transit to the actual quayside ; fourthly, they will discharge grain from vehicles at the quayside into ocean-going ships.

To meet these requirements the road trailers comprise the one main and two auxiliary vehicles which can be seen in the accompanying illustrations. The main trailer carries a suction/blowing equipment which can withdraw grain under suction from one point and discharge it under pressure to another point ; this unit can be used either alone or in combination with either of the two auxiliary units, one of which carries grain cleaning and weighing machinery, whilst the other carries weighing machinery only. Under the contract twenty-four main trailers and twelve each of the two auxiliary trailers are being supplied.



Weighing and Cleaning Unit

In normal service twelve of the suction/blowing units will operate with the twelve cleaner/weigher units for discharging incoming grain from road and rail vehicles into huts. In this way all grain will normally be cleaned and weighed before being put into storage in the dock area. The same twelve suction/blowing units will be used alone for transferring grain from huts to vehicles for transit to ships at the quayside. At the quayside the other twelve suction/blowing units will operate with the twelve weigher units for loading weighed consignments of grain into ships. Portable lengths of steel piping and flexible piping with quick-acting couplings are provided for connecting the suction/blowing trailers to grain intake and delivery points, and for interconnecting the main trailers with the auxiliary trailers when required.

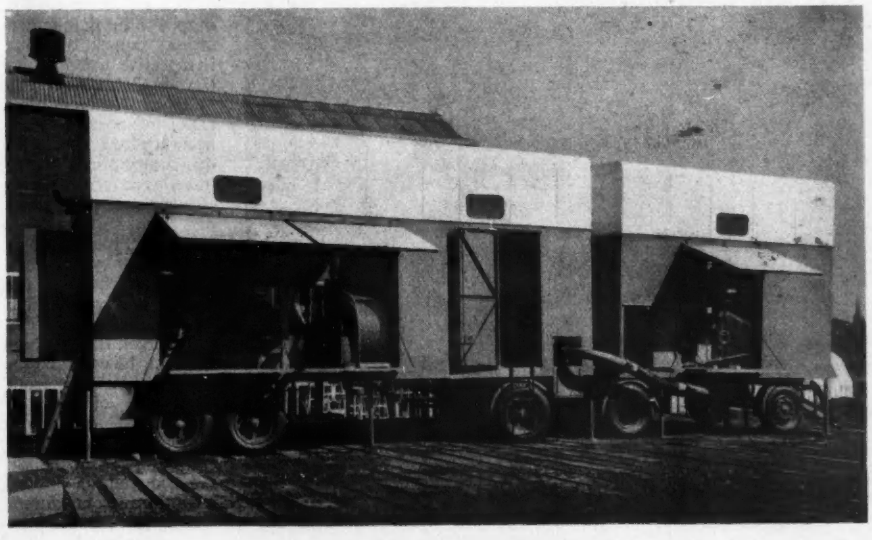
The main trailer carries a Roots exhauster, driven by a 165 h.p. diesel engine. The exhauster is used to provide suction for the intake of grain from vehicles or storage huts and pressure for the discharge of grain to delivery points. This trailer also carries the grain receiver and main pipe connections. In the unit incoming grain is delivered under suction to the grain receiver, where it is separated from the conveying air stream by a cyclone mounted inside the receiver. The air then passes into the suction inlet of the exhauster by way of a grid, for arresting airborne particles, and is discharged under pressure into the exhauster outlet pipe.

Grain is discharged from the receiver through a rotary air seal, on leaving which it can follow any of three alternative routes. When the main trailer is used alone the grain can be delivered straight into the exhauster pressure pipe to be blown to any desired delivery point. Alternatively, the grain can be diverted through a hand-operated valve into a chute feeding to portable belt conveyors, and when the main trailer operates in combination with one of the auxiliary trailers the grain is delivered by way of this chute into the boot of a bucket elevator mounted in the auxiliary trailer.

Each cleaner/weigher unit contains an " Apex " rubble separator and a pair of " Reform " automatic weighers mounted side by side. Grain from the suction/blowing unit is received in the boot of a bucket elevator, which discharges it into the rubble separator. Rubble removed from the grain is delivered to sacking-off points on each side of the trailer, whilst the cleaned grain is fed by a second bucket elevator into the top hoppers of the two automatic weighers. The weighed grain is then delivered through a pair of rotary air seals into a pressure delivery pipe coupled up from the exhauster outlet of the suction/blowing unit. A small diesel engine on the trailer drives the bucket elevators, rubble separator and rotary air seals.

A weigher trailer is similar to a cleaner/weigher trailer except that it has no rubble separator and only one bucket elevator. Grain from the suction/blowing unit is delivered into the boot of this elevator and fed to the weighers, from which it can be delivered on each side of the trailer through rotary air seals connected to an extension of the pressure outlet pipe from the suction/blowing unit. In this trailer there is also provided a small diesel engine for driving the bucket elevator and rotary seals.

Each of the three types of trailer has a chassis built up of rolled steel sections strongly braced by cross members. The main suction/blowing



Intake Unit and Weighing Unit

trailers are mounted on three axles and the auxiliary trailers on two, all wheels being fitted with large-section pneumatic tyres. Adjustable screw jacks fitted at the corners of the chassis are used to keep the trailers level and steady while operating.

The machinery on each trailer is enclosed in a rectangular sheet steel housing with large access flaps at the sides. During operation the upper flaps are opened upwards and supported on stays, and the lower flaps are opened downwards and held horizontally to provide extra floor space as shown in the illustrations. All the trailers are equipped with generators and storage batteries for internal electric lighting.

The suction/blowing unit is designed to receive and discharge grain at a rate of 45 tons per hour when collecting, and to deliver the grain over distances up to 100ft. The cleaner/weigher and weigher units can each handle up to 50 tons per hour, this capacity giving a small reserve to prevent any risk of overloading the cleaning and weighing machinery when the suction/blowing units are working at maximum capacity.

As mentioned at the beginning of this article, the equipment was ordered by the Turkish Government as an emergency measure, and the rapidity with which Simon Handling Engineers, Ltd., is carrying out its contract is worth mentioning. The order was placed during a period of considerable difficulty as regards deliveries of steel and components, but we are informed that notwithstanding these handicaps the first batch of fifteen trailers was ready for inspection and acceptance by Turkish Government representatives within ten months of the placing of the order, and the entire contract is scheduled for completion by September this year.

A Double-Head Vertical Grinding Machine

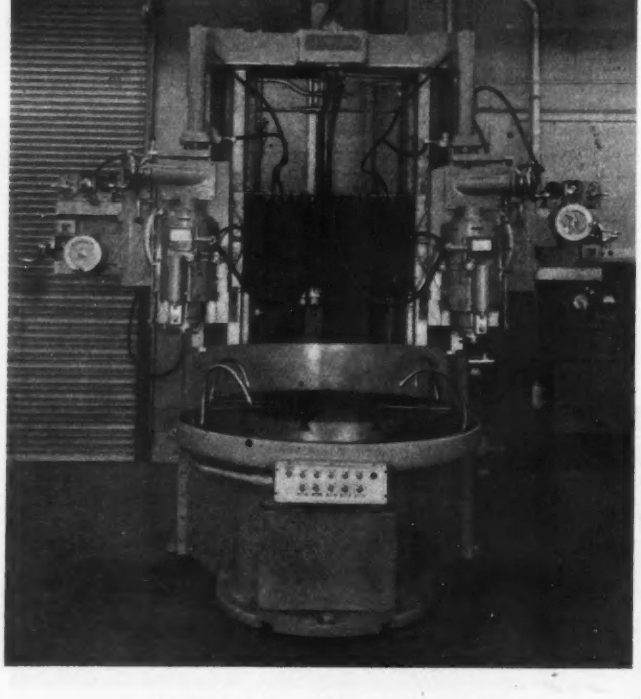
THE double-head heavy duty precision grinding machine, shown in the illustration on this page, is made in the United States by the Fraventhal Division of the Kaydon Engineering Corporation and distributed in this country by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11. It has a 48in diameter table designed to swing work up to 56in diameter, and when the grinding head cross rail is fully raised it gives a clear height of 36in above the table.

The table of the machine is driven through a variable-speed unit and worm gearing by a 3 h.p. motor, and in a standard machine it can be rotated from 5 r.p.m. to 35 r.p.m. The heavy spindle of the table is carried in preloaded roller bearings, the lower one of which is self-aligning and is designed to permit expansion or contraction of the housing due to temperature changes without affecting the initial accuracy of the machine.

The rigid box-section columns are coupled together at the top by a heavy rail and have accurately machined ways on which the main cross rail carrying the grinding heads is adjustable for height through handwheel-operated screws. The cross rails incorporate means of angular adjustment for correcting any error of alignment with the table surface. Non-metallic ways of synthetic phenolic material are fitted to the horizontal slides.

Each grinding head is a self-contained unit mounted on a vertical slide and driven by a 7½ h.p. motor at 1800 r.p.m. The spindles, which have a vertical travel of up to 12in, are designed to take wheels of 14in maximum diameter. The heads can be traversed a distance of up to 3ft along the cross rail and each head can be swivelled on its slide to give a wide range of angular wheel settings.

Hydraulic units are fitted for oscillating the grinding head spindles and the heads along the cross rail during the grinding operation. Adjustable stops are used to control the length of stroke, the rate of travel being infinitely variable between 1in and 120in per minute through a valve adjustment.



Double-Head Precision Grinding Machine

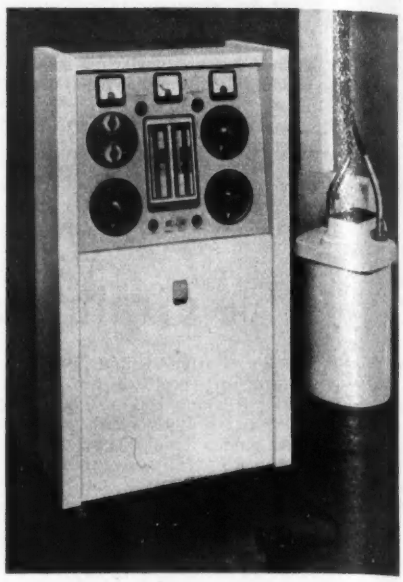
A Medium-Power X-Ray Generator

OUR illustration shows an X-ray generator known as the "Roentgen 100," which was recently introduced by Watson and Sons (Electro-Medical), Ltd., a subsidiary of the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. The equipment is a medium-power generator, which is suitable for use in conjunction with a single or double-focus X-ray tube for radiography, fluoroscopy and occasional superficial therapy.

As illustrated herewith, the generator consists of a self-rectifying transformer unit (right) and a mobile control table (left), the two units being connected by cables in a flexible sheath. In the transformer unit both the high-tension and filament transformers are immersed in insulating oil in a circular steel tank with a terminal panel and outlets for shockproof high-tension cables at the top. No valves are used in this equipment.

All the controls and measuring instruments are grouped together at a convenient height on a sloping plastic panel on the mobile control desk. A line compensator control, used in conjunction with a line voltmeter, enables the output to be maintained at a constant value irrespective of fluctuations in the mains supply voltage. Radiographic exposures are timed with accuracy by a synchronous motor timer, which has a large, clearly marked scale covering a range of from 0·05 to 8 seconds. Fluoroscopy is controlled by a foot switch attached to the control unit by a flexible lead, as illustrated. The "Roentgen 100" generator can be operated on most a.c. supplies from 100V to 260V, 50/60 c/s, whilst on 40-c/s supplies the apparatus can be used at a slightly reduced output. Consumption at maximum load on 200/250V supplies is approximately 60A.

As already indicated, the apparatus, although intended primarily for radiography, may also be employed for superficial therapy. If a Machlett "Aeromax BD" stationary anode tube is used, it can be operated at up to 85kVp 5mA continuously for periods up to fifteen minutes, whilst the "Dynamax 20" rotating anode tube can be loaded at the same ratings for three minutes in every five. The duration of treatment is measured by stopwatch or an external timer, the tube current being switched on and off at the control panel.



Medium Power X-Ray Generator

Materials Handling Report

THE report of the Technical Assistance Mission, No. 42, has recently been published with the title "Materials Handling Equipment and Methods in the U.S.A." It is concerned with handling problems from the point of view of shop organisation and manufacture rather than that of productivity. It begins with an outline of materials handling technique, such as research to eliminate unnecessary movement, analysis of essential handling, the choice of the cheapest and most efficient machinery and the use of models to decide upon the equipment to be adopted. The use, manufacture and mechanical details of the main handling devices are considered and descriptions given of the latest models of bulk products conveyors together with notes regarding their installation and output. There is a similar description of manufacturing processes with special reference to technical matters and all items are illustrated in the report by drawings and photographs. Conveyors for packaged goods are reviewed and the mission notes that considerable use is made of automatic devices to reduce labour costs and to reduce the time wasted by skilled workers. The reasons for choosing a particular design of conveyor are analysed from both the technical and economic points of view and the report goes on to give details of overhead chain, roller and pulling conveyors, while the differences are noted between the American and European techniques in manufacturing components and assembling equipment. The report contains technical information of considerable use to European manufacturers and this is followed by information on mobile and fixed hoisting equipment including some built to special requirements. There is a full description of the wide variety of trucks used in industry and a chapter on manufacturing methods which contains particulars of many forms of trolleys, such as straddle carriers used for timber transport. The report concludes with a number of practical examples of efficient handling organisation noted during the visit of the mission.

Industrial and Labour Notes

Government Expenditure and Industry

In the course of an address at a luncheon of the American Chamber of Commerce in London last week, Sir Harry Pilkington, the President of the Federation of British Industries, surveyed the views, achievements and opportunities of British industry. He first dealt with economy in Government expenditure, which, he said, was the concern of business men in both countries. High taxation implied a reduction in private savings and a diversion of resources, men, money and materials, mainly to unproductive uses financed by Government. Governments were not able to finance themselves as industry had to, so they turned to industry and the nation for extra finance and levelled taxes on savings and profits. But from its profits industry had to find means of modernising, improving and expanding plants. It was to private savings almost alone that industry had to look for investment in new enterprises and new expansion—and only in that way could national wealth and economy grow at a rate that would permit much of the present Government expenditure to continue at all.

Sir Harry pointed out that every productivity team that had visited the United States had drawn attention to the vital need for more capital equipment and more power in industry. If the Government took money, from which alone this equipment and power could be provided, it was in effect giving greater importance and higher priority to the other purposes for which it imposed taxation. Business men believed that that could not continue and that the only way to improve living standards in the United States and Great Britain was by greater efficiency and lower costs, by higher productivity all round, and by the devotion of the major part of potential national savings to industrial re-equipment and expansion. If we were to expand and modernise then the Government would have to deny itself and leave industry with the wherewithal for expansion. The last Budget, said Sir Harry, indicated that this view was shared by the Government of this country, and although the relief given to industry was not great, he believed it was a first instalment.

Ministry of Labour and National Service Annual Report

The annual report of the Ministry of Labour and National Service, published on Thursday, July 23rd, shows that for the first time for several years there was a slight decrease in the total working population of this country. During 1952 the number of men in the working population increased by 1300, whilst the number of women declined by 35,000, a net decrease of 22,000. The total working population at the end of 1952 was about 23,292,000. A decline in industrial activity was accompanied by a reduction in the number of unfilled vacancies, which in December stood at 230,000, as compared with 313,000 in December, 1951. The strength of the Armed Forces rose by 20,000 to 872,000, which represented 3¾ per cent of the total working population in 1952.

A brief survey of the manpower position in various industries shows that there was a notable increase in the coal mining labour force during the year. In transport the demands for labour were considerably eased, whilst the inflow of workers to railway services improved considerably and wastage decreased. The general level of unemployment was higher than for the last four years, mainly as a result of the continued decline in activity in the textile industries and those making consumer goods. In December the number of employed was 399,500, as compared with 303,000 in December, 1951, and 330,300 in 1949.

During the year negotiations on claims for increases of wages took place in most of the major industries of the country. The number of disputes and working days lost were 1714 and 1,792,000 respectively, as compared with 1719 and 1,694,000 in 1951. The loss of working time was slightly below the average of the post-war years and also of the past twenty years. There was a great reduction in the number of working days lost in the transport industry, the total of 32,000 being little more than 5 per cent of the corresponding figure for 1951. In all, 320 disputes were settled by agreement following action taken by the Ministry's Conciliation Officers.

More than 130 disputes were settled by voluntary arbitration, 71 being dealt with in the Industrial Court, 25 by single arbitrators, 4 by Boards of Arbitration, and 4 by independent chairmen appointed with powers to act as arbitrators; in addition, the Civil Service Arbitration Tribunal dealt with 53 claims. More than 200 cases were referred to the compulsory arbitration of the Industrial Disputes Tribunal.

Joint Statement on the Proposed B.E.C./F.B.I. Fusion

In December, 1946, following earlier discussions on the possibility of fusing the British Employers' Confederation and the Federation of British Industries, the two organisations adopted resolutions accepting fusion in principle. A joint statement has now been issued following the work of a joint committee which was appointed at that time to prepare a complete scheme acceptable to both organisations. Following exhaustive discussions with a view to working out a practicable scheme, the committee came to the conclusion that the increased work of the two organisations and the different character of the problems with which they deal, together with factors of their historical development, would inevitably result in the administration of any fused body being very cumbersome. These considerations convinced the committee that it was desirable to recommend to the two bodies, in the circumstances that have developed since the war, not to proceed further with fusion and satisfied it that the interests of British industry would best be served by maintaining in existence two separate organisations, working closely together, but each responsible for handling matters which fall within its respective province.

In January, 1945, following the termination of the earlier discussions and in order to facilitate subsequent fusion, it was arranged that the British Employers' Confederation should move its offices to 21, Tothill Street, Westminster, S.W.1, the existing headquarters of the Federation of British Industries. As the circumstances which led to this decision no longer obtain, the British Employers' Confederation has decided to establish its offices at a new address in the near future. Contact between the presidents and consultation between the two staffs have, in fact, greatly increased during the last seven years, and this has been further developed by co-operation in the activities of other bodies so that over a wide field collaboration has been close. Even though fusion is no longer contemplated, these methods of working together are still available and will be extended by regular meetings between the presidents. In the existing circumstances this is considered to offer the most effective means of achieving a common view in all matters of common interest, and, concludes the statement, it is the firm intention of both bodies to realise this objective.

Production Costs and Exports

Last week the quarterly meeting was held of the Minister of Labour's National Joint Advisory Committee, on which there are represented the British Employers' Confederation, the Trades Union Congress and the nationalised industries. At this meeting the council considered the question of developing a fuller appreciation of export production problems—a subject first discussed with the leading industrial organisations by the Chancellor of the Exchequer, Mr. Butler, in December last, and also by the council last February. The Chancellor attended the meeting to make a statement on the necessity of expanding this country's exports and the difficulties involved. After enumerating five particular reasons why exports at their present level were not satisfactory, Mr. Butler went on to say that this country could not meet competition if it had to grapple with rising costs of production in the factory. Profits were obviously an important element in the make-up of industrial prices, but between 1947 and 1952 the gross trading profits increased by 35 per cent and the wages and salaries by 50 per cent.

Mr. Butler then pointed out that it was essential that adequate sums of money should be available for ploughing back into industry for the renewal and modernisation of plant and the extension of productive capacity. National strength would be impaired if resources that ought to be devoted to re-equipment and development were taken to benefit personal incomes, whether they be enjoyed by wage-earners or shareholders. He said that the largest element in production costs were those of labour, and during 1952 the wage and salary bill rose by some £550 million, despite the fact that the level of industrial production was below that of 1951. A 10 per cent increase in wages and salaries throughout the manufacturing industry without a corresponding rise in productivity would, said Mr. Butler, cause a rise of 4½ per cent in export prices. If increases in fuel and transport costs were also taken into account, it was clear that the effect would be to put up average export prices by more than 1s. in the pound.

Iron and Steel Prices

The Minister of Supply has made an order which removes from price control certain iron and steel products. These products include colliery arches, pit props, cold drawn tubes, malleable iron pipe fittings, wire and wire products and assembled railway wheels and axles. The supply of these products, which do not come within the scope of the Iron and Steel Board, is now generally adequate.

In addition the order reduces by 7s. 6d. per ton the maximum permitted price of heavy steel products delivered to South Wales. This order came into effect on July 27, 1953.

Engineering and Shipbuilding Wages

On Tuesday of last week, representatives of the Confederation of Shipbuilding and Engineering Unions formally presented to the Engineering and Allied Employers' National Federation a claim for a 15 per cent increase in the wages of adult male workers in the engineering industry. It is understood that the claim is based on increased productivity in the industry, the high level of profits, and on the increased cost of living. If granted in full, the increase would amount to about £1 a week for skilled workers and 17s. 6d. for unskilled workers. The Employers' Federation stated that it would give detailed consideration to the claim and arrange a further conference with the union representatives.

Last Friday, a similar claim was presented to the Shipbuilding Employers' Federation on behalf of workers in the shipbuilding and ship repairing industries.

Alkali Works Inspectors' Report

The report for 1952 of the Chief Alkali Inspector of the Ministry of Housing and Local Government deals at some length with the problem of dust emission from cement works in England and Wales. It points out that the high demand for cement continued unabated and considering the intensive production complaints were probably inevitable.

Failure of electrical precipitators used for the de-dusting of kiln gases was a matter for grave concern. Most of the trouble had been of mechanical origin, due chiefly to corrosion of parts within the precipitator. Discussions had been held with the industry as to the means to be taken to reduce to the minimum condensation and the consequent corrosion.

The report goes on to say that progress in dealing with low level dust emissions from grinding, bagging and so forth continued at a reasonably satisfactory rate and the next few years should see all works equipped to deal with the problem.

Notes and Memoranda

Rail and Road

A NEW 20-CWT. VAN.—A 20-cwt. forward control van, incorporating flush sliding doors, large section low-pressure tyres and 2·2-litre o.h.v. engine, has been announced by Morris Commercial Cars, Ltd. The design of the interior and low-built floor give the van body a capacity of 235 cubic feet and the slightly curved rear doors hung on outrigger hinges can be folded back and secured against the body sides for delivery work and loading in confined spaces. The sliding doors of the cab have similar advantages and are much safer than those opening outwards. Production is to commence almost immediately.

ROAD ACCIDENTS.—Reports so far received by the Ministry of Transport show that road casualties in this country in June numbered 20,459. This is 1099 more than in June last year and includes 407 killed, an increase of twenty-five. The final total for May was 21,178, the highest figure for this month since 1937. Deaths numbered 432 and, compared with May of last year, 2080 more persons were injured and eighty more killed. These figures bring the total road casualties in the first six months of 1953 to 103,279, an increase compared with the same period last year of 8122. The death roll increased by 184 to 2274.

Air and Water

NEW DRY DOCK.—At the launch of the "British Merchant," Mr. J. W. Elliot, the chairman of Swan, Hunter and Wigham Richardson, Ltd., disclosed that the company planned to build a new dry dock at Wallsend which would be of a size sufficient to accommodate oil tankers up to 45,000 tons.

FRENCH MERCHANT FLEET.—It is stated by the French Ministry of Merchant Marine that the merchant fleet totals 753 ships of 3,499,534 tons, which represents an increase of more than 760,000 tons over the 1939 total. The tonnage of cargo vessels and oil tankers has increased but the number of liners included in the fleet has fallen from 146 to 88.

"CUTTY SARK."—The site proposed for housing the "Cutty Sark" between Greenwich Church Street and King William Walk, will occupy about two-fifths of an acre and its preparation requires the demolition of thirteen houses. To float the ship into position will involve cutting a channel and temporarily dismantling part of Greenwich Pier and the watermens' steps known as Garden Stairs.

MOBILE CRANES IN SHIPBUILDING.—A recent innovation in the shipbuilding industry is the employment of large-capacity mobile cranes to perform a primary role in ship construction, and we are informed that two Coles mobile cranes Mk. S.2310 are so employed in the yard of the Fairfield Shipbuilding and Engineering Company, Ltd. Each crane has a 60ft jib, capable of lifting a 14-ton load, which can be extended to 80ft or reduced to 30ft when a 20-ton load can be handled.

CHAMBER OF SHIPPING.—At a council meeting of the Chamber of Shipping of the United Kingdom, held last week, the council agreed to recommend its members voluntarily, and without waiting for legislation, to adopt those recommendations in the Government report on oil pollution which are practical for shipowners to put into force right away. At a meeting of the General Council of British Shipping it was reported that the Liverpool Steam Ship Owners' Association had decided to make a similar recommendation to its members.

THE FAIREY "ROTODYNE."—The Fairey Aviation Company announces that it has been awarded a contract by the Ministry of Supply to construct a large helicopter, known as the "Rotodyne," for research purposes. The Fairey "Rotodyne," powered by two Napier "Eland" propeller turbines, will use the Fairey patented system of tip-driven jet rotors. The principles of the "Rotodyne" are such as to give a higher cruising speed than any other helicopter. The real significance of the "Rotodyne" is that it will be the first rotating wing aircraft to offer a direct transportation challenge to the long-established, fixed-wing DC-3 ("Dakota"), for which a replacement has long been sought. Although it has the vertical thrust shaft of the helicopter, it employs stub wings on which forward thrust screws and engines are mounted, and with which it could make an emergency let down and landing independent of the rotor.

COLD-AIR UNIT FOR AIRCRAFT.—de Havilland Propellers, Ltd., has announced that, following nearly twenty years of association with United Aircraft Corporation of East Hartford, Connecticut, U.S.A., it has been granted the manufacturing licence for the Hamilton Standard Cold-Air Unit for aircraft. Cockpit refrigeration is now essential in high-speed aircraft. A jet fighter flying at 600 m.p.h. at sea level can develop a cockpit temperature of 190 deg. Fah. Of this temperature 50 per cent arises from the friction of the aircraft's passage through the air, 40 per cent from solar radiation and the final 10 per cent from the aircraft's electrical equipment and the heat of the pilot's own body. The de Havilland unit, which is capable of extracting 150,000 B.Th.U.s per hour, works on the expansion principle and comprises a turbine-driven fan working in conjunction with one or more heat exchangers. It is designed for use with jet or turbine-propeller aircraft which are pressurised by air drawn from the engine compressor. Plans are now being made for the production of the de Havilland Cold-Air Unit at the Lostock factory of de Havilland Propellers, Ltd., near Bolton, in Lancashire.

Miscellanea

RESEARCH FELLOWSHIP FOR BIOSYNTHESIS.—A fellowship of £500 a year for three years has been granted by Dunlop Rubber Company, Ltd., at Birmingham University for research work on biosynthesis with special reference to rubber.

DEATH OF DR. G. L. KELLEY.—On Saturday last, July 25th, Dr. George Leslie Kelley died at Oxford, at the age of seventy-two years. Dr. Kelley was formerly managing director and scientific adviser to the Pressed Steel Company, of which he became vice-chairman in 1948. As a metallurgist Dr. Kelley made a particular study of the manipulation and uses of steel.

CONTROLLER OF MUNITIONS SUPPLIES.—The Ministry of Supply and the War Office announce that, with the Queen's consent, Major-General W. J. Eldridge, C.B., has been appointed Controller of Supplies (Munitions) by the Minister of Supply in succession to General Sir Kenneth N. Crawford, K.B.E., with effect from October 1st next. Major-General Eldridge will be granted the temporary rank of Lieutenant-General on taking up this appointment.

I.E.E. SUPPLY SECTION.—The Supply Section of the Institution of Electrical Engineers will be holding its annual summer visit in Porthcawl, South Wales, from September 24th to 27th. The programme will include visits to the Llandarcy Oil Refinery, the Abbey Steel Works at Margam, the Metal Box Company at Neath, and to a colliery and a woollen mills. Further details may be obtained from the Secretary of the Institution, Savoy Place, London, W.C.2.

RETIREMENT OF MR. E. W. SPALDING.—We are informed by Ruston and Hornsby, Ltd., that Mr. E. W. Spalding, a director of the firm since 1947, has just retired. Mr. Spalding had spent the whole of his working life, more than fifty years, with the firm. In 1931 he became manager of the overseas department, in 1940 general sales manager, and in 1944 commercial manager, a post which he held with his directorship until his retirement. Mr. C. T. Alderson has been appointed commercial manager of the firm in succession to Mr. Spalding.

EXPORTS OF ELECTRICITY FROM YUGOSLAVIA.—The United Nations Economic Commission for Europe announces the creation of an international body called "Yougelexport," which is an association of four committees created to handle economic, technical, financial and legal aspects of developing Yugoslav production of electricity for export to neighbouring countries. It is suggested that "Yougelexport" may develop into an important international hydro-electric power company. Its charter members are Yugoslavia, Austria, Italy and Western Germany.

EMBOSSED ALUMINIUM.—We have been informed by the British Aluminium Company that the company is now producing sheet material with a new finish named embossed aluminium. The embossing operation work hardens the metal and by increasing the overall thickness of the sheet provides a considerable stiffening effect, while the surface breaks up light reflections and is less apt to show incidental marks. Two patterns are available in flat sheet, namely light stucco and heavy stucco, in commercial purity aluminium, to standard specification S.I.C., and to standard specification N.S.3 in soft and half-hard tempers and thicknesses ranging from 24 to 16 S.W.G.

THE INSTITUTION OF MINING ENGINEERS.—Major Noel E. Webster has been elected president of the Institution of Mining Engineers for 1954–55, and will succeed Professor J. Cecil Mitcheson at the sixtieth annual general meeting to be held in London on Thursday, January 28, 1954. Major Webster, who was born in 1893, has been a member of council since 1934 and was president of the Midland Institute of Mining Engineers in 1943–44. He received his early training under Professor McMillan at University College, Nottingham, and later under Mr. J. T. Todd, of Blackwall Collieries, Derbyshire. He obtained his colliery manager's certificate in 1919.

BRITISH OFFICE MACHINERY EXPORTS.—The Office Appliance and Business Equipment Trades Association states that this country is now second only to the U.S.A. as the world's major source of supply of office equipment and last year America not only increased imports from Britain by 660 per cent over 1950 but became this country's best overseas customer. Overall, Britain's office machinery exports to the world dropped slightly from £5,137,816 during the first six months of 1952—which was nearly £1,000,000 more than during the same half of 1951—to £5,050,467, but as this deficiency was even less than that experienced in the Brazilian market alone, where severe sterling economies are in operation, the industry can be considered to be more than holding its own.

THE ENGINEER'S GUILD.—The Scottish Branch of the Engineer's Guild has extended an invitation, during the Edinburgh Festival of Music and Art, to fellow members who may be visiting the Scottish capital. To avoid interference with visitors' plans, the welcome will be informal and flexible, consisting of a cocktail party at which the hosts may meet their visitors, and visits to works and plants which may be individually arranged between members. Members of the Guild who expect to be in Edinburgh between August 23rd and September 12th are asked to communicate with Mr. C. M. Beckett, 8, House o'Hill Row, Edinburgh, 4 (Edinburgh 77785), so that details of the arrangements, which will be finally made to suit the majority of visitors, can be sent to them.

STANLOW REFINERY.—A new plant to remove sulphur from petroleum products is now under construction at the Stanlow oil refinery of the Shell Petroleum Company, Ltd., and is expected to be ready for operation next year. This "hydrodesulphurisation" plant enables the sulphur content of oils to be materially reduced and differs from the conventional vapour phase procedure, in that the process is effected by a "trickle" technique. This is so called because the feedstock trickles in liquid form over the bed of catalyst in the presence of hydrogen under pressure, and after meeting a circulating stream of hydrogen the oil is heated and passed over a fixed bed of catalyst, cobalt molybdena on alumina. The reactor pressures are of the order of 300 lb to 750 lb per square inch gauge, while the temperatures range from 650 deg. to 730 deg. Fah. and the sulphur reduction of between 85 per cent to 90 per cent can be effected with very little attack of the cracked or high aromatic components present in the feedstock.

CARDON REFINERY.—The temporary switchgear which has enabled the Cardon refinery of the Shell Petroleum Company, Ltd., in Venezuela to continue operations after a fire in the power-house had destroyed the existing switchgear is now being replaced by new equipment. This has been completed by A. Reyrolle and Co., Ltd., in about six months and consists of a twenty-eight panel metalclad switchboard associated with a thirty-two panel control board. For the main 6600V switchgear at the refinery power station Reyrolle pattern B.3.T. metalclad switchgear of duplicate busbar construction has been supplied. The busbar chamber, current transformer chambers and cable boxes are compound filled and the horizontal drawout oil break circuit breakers are solenoid operated. They incorporate "Turbulator" arc control devices and have a proved breaking capacity of 500MVA. The switchboard is in three sections with provision for a fourth, and each section of the switchboard and each busbar section panel are in separate compartments with fireproof doors and protected by automatic CO_2 equipment. The busbars are protected by a system of leakage-to-frame protection and the whole equipment will be housed in a new switchhouse having fireproof doors.

Personal and Business

MR. S. F. WISE has relinquished his appointment with Baker Perkins, Ltd., Peterborough, as manager of purchasing, material control and stores.

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS informs us that its telephone number has been changed to HYDe Park 4126/7, HYDe Park 1557/8.

STANLEY HOWARD, Ltd., 75–76, Exchange Buildings, Stephenson Place, Birmingham, 2, announces that it is forming an organisation for the export and sale of British machine tools to Germany, Switzerland, France, &c. The firm already has an office in Cologne.

MR. K. P. WOOD, M.A. (Cantab.), informs us that he has resigned from the board of James Beresford and Son, Ltd., Birmingham, and has severed his connection with the company. He joined the company as sales manager in 1933, subsequently being elected to the board in 1945.

MR. C. W. A. PRIEST, B.Sc. (Eng.), A.M.I.Mech.E., M.I.E.E., Generation Engineer (Construction) of the Southern Division of the British Electricity Authority, has been appointed Chief Generation Engineer (Construction) of the South Wales Division. He succeeds Mr. T. H. Wood, M.I.Mech.E., A.M.I.E.E., who recently retired.

MR. C. R. BATES, A.M.I.E.E., has given up his practice as a general industrial electronic consultant in order to specialise in electronic welding controls. He has been appointed a director of a company manufacturing synchronous controls to his designs and patents. Inquiries should now be addressed to Bates and Bates, Ltd., 73, Ashville Avenue, Birmingham, 34.

THE directors of Wickman, Ltd., Coventry, announce that Mr. H. Eckersley, M.I.Mech.E., M.I.P.E., general manager of the Wimet Division, and Mr. W. V. Hodgson, M.I.P.E., general manager of the Machine Tool Division, were appointed to the board of the company on July 15, 1953. With the increase in the company's activities the directors decided to establish a local board and appointed as special directors Mr. R. J. Dixon, chief engineer; Mr. T. W. Hayes, export sales manager; and Mr. S. W. Perkins, machine tool sales manager.

RUSTON-BUCYRUS, Ltd., Lincoln, announces that, at his request, Mr. W. Savage, C.B.E., M.I.Mech.E., is relinquishing his present duties and responsibilities as works director and chief engineer. Mr. Savage has, however, agreed to defer temporarily his retirement mainly to undertake some special engineering development work; while so doing he will continue as an executive director. Mr. J. H. Page, A.M.I.C.E., A.M.I.Mech.E., has been elected to the board of directors and appointed to the position of technical director. Mr. P. H. R. Durand, B.Sc. (Eng.), A.M.I.E.E., A.M.I.Mech.E., has been appointed chief engineer.

THE directors of the Brush Electrical Engineering Company, Ltd., have agreed, at the request of Simms Motor Units, Ltd., to release Mr. John Ayres, at present managing director of Petters, Ltd., Staines, from his service agreements with the Brush Group, to enable him to take up the appointment of general manager and director of Simms Motor Units, Ltd., on October 1, 1953. Captain R. C. Petter will, as from that date, be appointed managing director of Petters, Ltd., and he will assume the responsibilities of that office on a temporary basis until it is possible for the board to make a permanent appointment.

British Patent Specifications

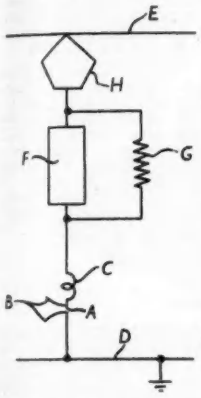
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

692,728. November 14, 1950.—ELECTRIC SURGE ARRESTOR ARRANGEMENTS, The General Electric Co., Ltd., of Magnet House, Kingsway, London, W.C.2, and Edward Hugh Croft, The General Electric Co., Ltd., Engineering Works, Witton, Birmingham.

The invention relates to electric surge arrestor arrangements and is particularly concerned with direct current supply systems, for example, electric traction in which vehicles or locomotives are supplied from overhead lines and surge arrestor arrangements are provided either on the line or on the vehicles themselves. In the accompanying drawing, surge absorbing apparatus for use on a traction system using a 1500V d.c. supply to an overhead line has a spark gap *A* fitted with arcing horns *B*, the spark gap being arranged to flash over at a voltage of approximately 6000V. A blowout coil *C* for providing a magnetic field in the region of the arcing horns is connected in series with the spark gap, one side of which is connected to a line *D* which is earthed. The opposite side of the spark gap is connected through the blowout coil *C* to the other line *E* through a silicon carbide non-linear resistance *F* connected in parallel with a linear resistance *G* (such, for example, as a metallic resistance, or a carbon resistance) and a pantograph *H*. Under normal conditions there is no flow of current through the surge arrestor, but when a surge occurs the spark gap *A* flashes over and allows a heavy current due to the surge to flow through the blowout coil *C* across the spark gap and through the linear and non-linear resistances *G* and *F*. Under such surge conditions the non-linear resistance *F* is arranged to present a substantially lower effective resistance to the surge current than the linear resistance *G*. When the surge has passed, an arc will be maintained across the spark gap *A* or arcing horns *B* by current flowing from one line to the other through the blowout coil *C* across the spark gap and through the linear and non-linear resistances. Under these conditions it is arranged that the total current flowing through the blowout coil *C* is sufficient to provide a magnetic field in the region of the arcing horns *B* of adequate strength to ensure extinguishing of the arc. For this purpose the linear resistance *G* may be arranged to pass, under these conditions, a current several times greater than that which is passed under these conditions by the non-linear resistance *F*. It is not essential that the linear resistance *G* above referred to should be precisely linear, the term "linear" being used to distinguish its characteristics from the characteristics of the silicon carbide resistance *F* with which it is connected in parallel. Whereas the silicon carbide resistance has a resistance characteristic which decreases with increase of current through the resistance, it is desirable that the other resistance *G* should have a resistance characteristic which does not decrease with increase of current. This feature distinguishes the invention from an arrangement in which two or more silicon carbide resistor elements may be connected in parallel with one another so as to share the current flowing through them.—*June* 10, 1953.

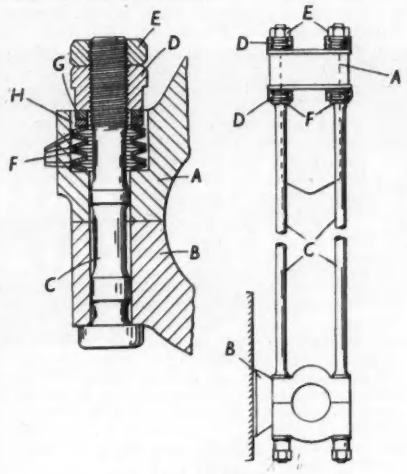


No. 692,728

INTERNAL COMBUSTION ENGINES

693,427. April 22, 1949.—INTERNAL COMBUSTION ENGINES, William Doxford and Sons, Ltd., and William Hamilton Purdie, both of Pallion Yard, Sunderland.

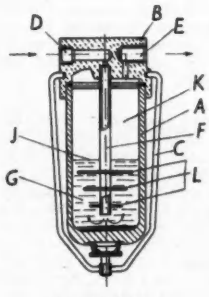
The drawings show two parts of a big end bearing and the connection between the yoke of the upper piston and the cross-head of an opposed-piston engine. In the left-hand view the parts *A* and *B* of the big end bearing of the engine are bolted together by means of a bolt *C* and nut *D*. A lock nut *E* is also provided. In accordance with the invention a pack of disc springs *F* is located in a recess in the upper half *A* of the big end bearing and applies a load through the co-operating distance washers *G* and *H* and nut *D* to the bolt. The disc springs are arranged so that, when unstressed, adjacent springs bow in opposite directions so that, as can be seen from the drawing, each spring contacts on one side of it only at the edge of its central aperture and on the other side of it only at its peripheral edge. A modified arrangement is also shown. The right-hand view shows the connection between the yoke *A* of the upper piston of an opposed piston engine and the cross-head *B* which transmits the power from the upper piston to the crankshaft. The connection is made by means of side bolts *C* of which there are four and each side bolt has two packs of disc springs *D* mounted on it; the upper pack is located between the top of the yoke and the nut *E* at the end of the bolt, and the lower pack is located between the bottom of the yoke and a flange *F* formed on the bolt. The packs of disc springs are chosen so that they do not tighten up solid in operation, and thus they have the effect of equalising the loads transmitted by the side bolts to the cross-head.—*July* 1, 1953.



No. 693,427

693,541. September 28, 1951.—APPARATUS FOR REMOVING SOLIDS FROM LIQUID FUEL, Ditta Fratelli Lombardi and Dotti, Rue Dante 7r, Brescia, Italy. (*Inventor: Michele Lombardi.*)

The invention relates to apparatus for removing, by washing, solid impurities from liquid fuel in the course of supply of the fuel to internal combustion engines. As illustrated, the apparatus comprises a bowl or cup *A*, preferably made of transparent material, and a top cover *B* detachably secured by means of a yoke *C* having a screw and a nut to engage the bottom of the cup, as shown. Thus, the two parts constitute a closed container. The cover has a fuel inlet *D* and a fuel outlet *E* connected with the engine fuel supply tank and the engine carburettor or fuel injection pump, respectively. A tube *F* constituting an extension or part of the inlet *D* extends from the cover nearly to the bottom of the cup, which is partially filled with water or washing liquid *G*. In use the fuel passes into the cup by the inlet and enters it near the bottom of the layer of washing liquid, whence it rises outside the tube and through the washing liquid to the fuel outlet and so to the engine carburettor or injection pump. Heavy solids or impurities entering the cup with the fuel are precipitated on the bottom, while lighter solids or impurities (having a density less than the washing liquid but greater than the fuel itself) float on the washing liquid at *J*. The treated fuel in the cup is shown at *K*. Vanes *L* are shown on the tube *F*, their purpose being to retard the upward flow of fuel through the washing liquid. By means of the apparatus solid impurities are separated from the fuel in a simple and reliable manner before the fuel passes to the engine fuel feed system, so that danger of the system becoming choked or obstructed is eliminated. Moreover, the slight moisture content of the treated fuel, this moisture being taken up from the washing liquid, improves the efficiency of the engine. Also the washing liquid is not likely to freeze in cold weather since it is protected by the fuel.—*July* 1, 1953.

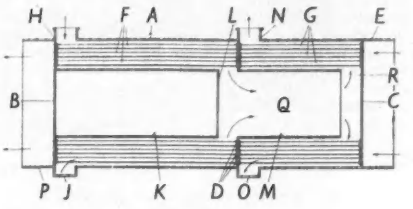


No. 693,541

GAS TURBINES

693,182. September 28, 1950.—HEATING AIR OR WORKING FLUID BY WASTE GASES, W. H. Allen, Sons and Co., Ltd., Queens Engineering Works, Bedford, and John Thomas Bosher Oxford, of the company's address.

The invention relates to gas turbine systems in which the waste heat from miscellaneous industrial plant is utilised for heating the working fluid of the turbine, and is concerned with a method for heating the air discharged from the compressor and passed to the turbine. As shown in the drawing, the heater comprises a shell *A* having end tube plates *B* and *C* and an intermediate tube plate *D*. A trunk or duct *E* at one end of the shell constitutes an inlet for the waste gases. A series of tubes *F* extend between the tube plates and are the first stage of the air heater. A second set of tubes *G* extend between the tube plates *D* and *C* and are connected to the tubes *F*, the tubes *G* being the second stage of the air heater. The tubes *F* and *G* may be continuous if desired, as shown, but preferably they are of different materials and are joined together. An air inlet *H* is connected to an annular chamber *J* forming part of the shell at the end remote from the gas inlet *E*. Within the group of tubes *F* is a cylindrical wall *K* extending to a point spaced from the tube plate *D*, where it is closed by an end wall *L*, its opposite end being closed by the tube plate *B*. The plate *D* has a central aperture joined to a cylindrical wall *M* extending to a point spaced from the tube plate *C*. An air outlet *N* is connected to an annular chamber *O* formed on the shell adjacent the tube plate *D* and on the side nearest to the gas inlet *E*. At the opposite end of the shell a trunk or duct *P* provides an outlet for the waste gases. The air entering the inlet *H* to the first stage of the heater traverses the interstices between the tubes *F* in heat exchange relationship and in contra-flow with respect to the waste gases in the tubes *G* and *F*. The air from the first stage passes into the space indicated at *Q* and thence through the cylindrical wall element *M* where it passes out through the space *R* into the interstices between the tubes *G* of the second stage at the waste gas inlet end. The air traverses between the tubes *G* in parallel-flow relation with the travel of the waste gases through the tubes. Owing to the flow relationship the temperature of the tubes *G* will lie between the temperatures of the entering air and the waste gas. In the specification the operating temperatures of each stage are given.—*June* 24, 1953.

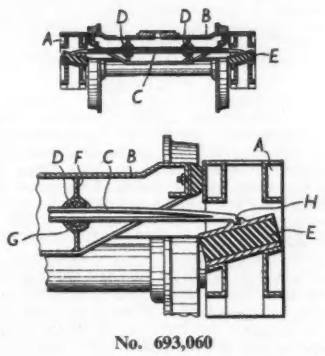


No. 693,182

BEARINGS AND SUPPORTS

693,060. February 7, 1951.—SPRING SUSPENSION OF BOLSTERS FOR AXLE-TRUCKS, Erik Hedin, 10, Strandgatan, Eskilstuna, Sweden.

The invention relates to a spring suspension of bolsters for trucks in which the bolster is supported at two places by transverse springs, the ends of which rest on resilient members mounted in the lateral portions of the frame of the bogie. In the drawing the upper view shows a cross-section of a truck, *A* indicating the frame of the bogie, *B* the bolster, *C* the springs, *D* the places of support, and *E* the resilient rubber members. The lower view shows to an enlarged scale one end portion of the cross



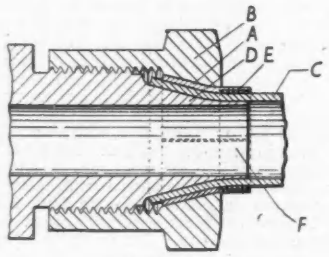
No. 693,060

sectional view. An object of the invention is to reduce, as far as possible, friction at the supporting places *D* without neglecting safety requirements. To this end, the springs *C* supporting the bolster are mounted in openings provided in intermediate walls *F* at the places of support *D*, which are tubular bearing-cases with closed ends and with openings through which the springs extend between two segments *G*. Due to the tubular shape of the casing *D* and the provision in it of the segments *G*, the degree of movement required for enabling the springs *C* to pivot about their supports *D* and to adapt themselves in accordance with the load, is obtained at a minimum of friction and with greatest possible security. To reduce the tendency towards rolling the resilient or rubber members *E* are mounted in slanting positions. If, for instance, the body of the carriage and consequently the bolster *B* are forced laterally towards the right under the action of the centrifugal forces, the ends *H* of the springs *C* will be moved upwards as a result of the slant of the rubber member *E*, whilst the left-hand ends of the springs will be simultaneously lowered. This movement of the springs will thus counteract the effect of centrifugal force. The invention is not limited to the details of construction described and may be modified, as to the mounting of the springs, within the scope of the claims.—*June* 24, 1953.

TUBE AND PIPE COUPLINGS

693,637. November 2, 1950.—PIPE COUPLINGS, High-Pressure Components, Ltd., 139, Kensington High Street, London, W.8. (*Inventor : Lewis Phillips Winby.*)

This invention relates to couplings for comparatively rigid pipes, such as are composed of material other than metal and which are liable to fracture as a result of vibration. As the drawing shows, a longitudinally split metal collet *A* is interposed between the sleeve nut *B* and outwardly flared end of the pipe *C* which engages the tapering end *D* of the coupling body. An annular ring *E* of synthetic or natural rubber is bonded into an annular recess formed internally in the end of the collet which projects from the sleeve nut, the rubber projecting from the collet an amount sufficient to produce an interference



No. 693,637

fit between the rubber and the peripheral surface of the pipe. The rubber ring damps any vibrations set up in the pipe, which might result in its fracture. In the case of a collet which is split longitudinally at one or more points, the annular ring will not be closed except possibly as a result of contraction of the collet and may comprise one or more part circular or segmental shaped components. It is preferred that the body of the coupling shall be extended as at *F* to enter the cylindrical straight portion of the pipe thereby providing an additional internal support for the pipe. The action of tightening the sleeve nut on the threaded part of the coupling body contracts the collet upon the flared end of the pipe, which is thus brought into close engagement with the tapered extremity of the coupling body.—*July* 1, 1953.

CIVIL ENGINEERING

692,741. March 6, 1951.—SHAPED EXPLOSIVE CHARGES FOR PERFORATING OPERATIONS, Société de Prospection Electrique, Procédés Schlumberger, 42, rue Saint-Dominique, Paris, France.

The invention relates to shaped explosive charges for perforating and cutting and like operations. The perforating device is fully described in the earlier Patent Specification, No. 677,824. The element is formed with a case containing the hollow or shaped charge, complete with the fuse for igniting it. It is inserted into the borehole casing or other member through a screwed plug. When the charge explodes the jet of gases ruptures the plug and perforates the pipe or casing as required. This invention consists in the provision of a surrounding mass of porous material such as metal shavings, sponge or trellis work over the charge, which reduces to a large extent the destructive effect of the transverse detonation waves, which otherwise might cause damage to the inner surface of the object being perforated.—*June* 10, 1953.

Technical Reports

The Permanent Effect of Water on Varnished Coils (Ref. A/T138). By H. R. Heap, B.Sc. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—Tests, made in general accordance with the method described in Report Ref. A/T124, have been carried out to determine whether subjecting coils impregnated with varnish to total immersion in water has a permanent effect on the moisture-resisting properties of the varnish. It is shown that varnished coils treated in this manner are permanently damaged.

Should these varnished coils form the winding of a motor operating under adverse moisture conditions and into which, due to some fault in protection, water may have entered, it is thought that drying of the winding will not restore the insulation to its original condition, unless the drying period is followed by re-impregnation of the coils.

Flameproof Electrical Apparatus. Re-Assessment of Values of Statistical Maximum Safe Gap on the Bases of the Integral Curve of a Normal Distribution (Ref. G/T279). By C. E. R. Bruce, M.A., B.Sc. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 6s., postage 3d.—The linear law, hitherto used in determination of statistical maximum safe gaps in E.R.A. reports on specific combustibles is now found to be an over-simplification in the face of accumulating experimental results on the 1in flange including a few recently available on the ¼in flange, and it has been decided to replace it by a more appropriate method of treatment.

This report describes the new method of assessment and tabulates the results, together with the earlier values for comparison, for all the combustibles used in industry on which work has so far been done. The new values are lower than those obtained by the earlier determination, but in most cases for the 1in flange the decrease is not sufficient to bring them below the existing lower limit for the S.M.S.G. values specified by the B.S.I. for the group concerned.

It should be noted that this report does not deal with the specified "permissible gap" which in general has a value much below the specified lower S.M.S.G. limit referred to in the last paragraph.

Examination of a Defective Creosoted Pole After Remedial Treatment by the Cobra Process (Ref. O/T10). By D. N. Smith. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—An examination has been made of sections of overhead line poles which have been given a remedial treatment to arrest the internal decay which had developed because the poles were not adequately creosoted in the first place. The results indicate that the treatment is effective where the decay occurs in the vicinity of the ground line, but that it is not likely to be effective against decay occurring beyond about 18in above the ground. Attempts are being made to discover at what height in the pole this internal decay most frequently occurs. Service trials are being carried out on this remedial process and the results, together with any information which may come to light on the incidence of this premature decay, will be the subject of a later report.

The Torsional Vibrations of Long Chain Molecules, III (Ref. L/T279). By B. Szigeti. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 6s., postage 3d.—this report describes a continuation of the work reported in Refs. L/T266 and 267. For isolated long chain ketones in the extended configuration, with the CO-group near the centre of the chain, the effect of the chain ends on the amplitude of the torsional oscillations of the CO-group is calculated. It is found that the importance of these end effects does not diminish with increasing chain length. If the number of carbon atoms is odd, then for the model discussed the mean square amplitude of the CO-group differs by about a factor 2 according to whether it is on the same side of the chain axis as the end groups or opposite to them. The frequencies of vibration are probably not much influenced by these effects.

Stabilisation of Impregnated-Paper Capacitors. Pilot Scale Tests with Azobenzene (Ref. L/T268). By H. F. Church. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—The effectiveness of stabilisers in retarding deterioration of paper capacitors impregnated with chlorinated hydrocarbons is already well known from laboratory experiments. The present pilot scale tests were designed to investigate the suitability of one stabiliser, azobenzene, for use under factory conditions.

The results show that the long lives under d.c. stress at elevated temperature previously attainable only with non-polar impregnants such as petroleum jelly are now possible with chlornaphtalene impregnant if 2 per cent of azobenzene is added. Freedom from contamination of the units and high purity of the impregnant and stabiliser are essential if the full benefit of stabilisation is to be obtained. Extensions of mean life up to thirty times with 2 per cent addition of azobenzene have been recorded. For long life kraft paper is to be preferred to linen paper and the difference is explained. Under the same stress conditions, a three-paper layer dielectric gives longer life than one having only two layers.

Launches and Trial Trips

BARON KILMARNOCK, oil tanker ; built by the Caledon Shipbuilding and Engineering Company, Ltd., for H. Hogarth and Sons, Ltd. ; length overall 548ft, breadth 71ft, depth 38ft 9in, deadweight 16,900 tons on 30ft draught ; nine centre and eighteen side tanks, two pump rooms ; 500 tons per hour horizontal duplex compound cargo pumps, steam deck machinery ; Kincaid two cycle, single-acting diesel engine, six cylinders 750mm diameter by 1500mm stroke, 6950 b.h.p. at 110 r.p.m. ; two horizontal boilers, one waste heat boiler ; two 100kW steam-driven generators, one 100kW diesel-driven generator. Trial, July 14th.

MERCHANT BARON, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the Drake Shipping Company, Ltd. ; length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, deadweight 18,000 tons, draught 30ft 6in ; twenty-seven cargo oil tanks, two pump rooms, four 500 tons per hour horizontal Duplex steam cargo pumps, two vertical Duplex stripping pumps, steam deck machinery ; two 60kW steam-driven generators, one 25kW diesel-driven generator ; N.E.M.-Doxford single-acting, two-stroke, opposed-piston oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m. ; two Scotch boilers.—Trial, July 20th.

BRITISH FLAG, oil tanker ; built by R. and W. Hawthorn Leslie and Co., Ltd., for the British Tanker Company, Ltd. ; length overall 547ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,200 tons ; twenty-seven cargo oil tanks, two pump rooms, four Duplex compound pumps, steam deck machinery ; two 150kW diesel-driven generators, one 75kW steam-driven generator ; Hawthorn-Doxford oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m. two auxiliary boilers.—Trial, July 22nd and 23rd.

Contracts

THE NORTHERN IRELAND MINISTRY OF COMMERCE has accepted a tender from Charles Brand and Son, Ltd., Haymarket, London, for the carrying out of improvement works at Kilkeel Harbour, Co. Down. The amount of the tender is approximately £110,000. The works are being carried out by the Ministry on behalf of the Down County Council and comprise the first stage of a two-stage scheme which has been designed primarily for the improvement of facilities for fishing vessels at Kilkeel Harbour. The works include the deepening of the entrance channel and the harbour mouth and the strengthening and modification of the existing piers at the harbour mouth. It is hoped that the contract will be completed in eighteen months.

NATIONAL OIL ENGINES (EXPORT), Ltd., has received from the Government of Burma an order for the propulsion and auxiliary machinery for fifty-six creek class single-screw motor vessels for service with Burma Inland Water Transport Department in the Irrawaddy delta. The machinery for each of the boats, which have a waterline length of 94ft 6in by 22ft beam, is identical, the propulsion engines being National R4AM4 four-cylinder marine diesel, developing 200 b.h.p. at 600 r.p.m. and driving through an oil-operated reverse reduction gearbox to transmit 160 s.h.p. to the propeller at 450 r.p.m. in service. The auxiliary sets consist of a Petter B2. two-cylinder diesel engine of 18 b.h.p. at 1500 r.p.m., driving a Hamworthy compressor, an 8kW generator and a centrifugal pump, and 3kW emergency generator sets driven by Petter A.V.1 single-cylinder diesel engines.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASLIB

Fri. to Mon., Sept. 11th to 14th.—The University, Nottingham, 28th Annual Conference.

ENGINEERS' GUILD

Thurs., Sept. 24th.—METROPOLITAN BRANCH : Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Aug. 18th.—Visit by a Party of Members to the Works of Scammell Lorries, Ltd., Watford, Herts, 10.45 a.m.